Final Feasibility Study

Former Maintenance and Fueling Facility
Skykomish, Washington

Volume One: Text, Tables and Figures

Prepared by:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, Washington 98134-1162

RETEC Project Number: BN050-16423-250

Prepared for:

BNSF Railway Company
2454 Occidental Street, Suite 1A
Seattle, Washington 98134

Washington State Department of Ecology
3190 160th Avenue S.E.
Bellevue, WA 98008-5452

March 15, 2005

Final Feasibility Study

Former Maintenance and Fueling Facility
Skykomish, Washington

Prepared by:

The RETEC Group, Inc.
1011 SW Klickitat Way, Suite 207
Seattle, Washington 98134-1162

RETEC Project Number: BN050-16423-250

Prepared for:

BNSF Railway Company
2454 Occidental Street, Suite 1A
Seattle, Washington 98134

Prepared by:

____

Grant Hainsworth, P.E., Senior Project Engineer

Reviewed by:

____

Halah M. Voges, P.E., Senior Project Manager

March 15, 2005

Executive Summary

The following is a summary of the key findings and conclusions presented in this Final Feasibility Study (Final FS) for the BNSF Railway Company's Former Maintenance and Fueling Facility in Skykomish, Washington.

Procedural Posture

A Draft Feasibility Study (Draft FS), which was integrated with a Draft Environmental Impact Statement (Draft EIS), was issued on September 3, 2003 for a 60-day public comment period. A Draft Final FS was submitted to Department of Ecology (Ecology) on July 26, 2004 that incorporated revisions to the Draft FS portion based on public and agency comments received in the Fall of 2003. A Final EIS will be issued by Ecology before a Cleanup Action Plan (CAP) is issued by the agency. Ecology will carefully consider public comment during preparation of the Final EIS and CAP.

After considering comments that BNSF and the agency received on the Draft FS and Draft EIS, BNSF developed a preliminary preferred alternative and included that in the Draft Final FS (RETEC, July 26, 2004). BNSF presented it's preliminary preferred alternative to Ecology and the community, collected additional information from technology vendors, revised it's preliminary preferred alternative and prepared a detailed description and analysis of the revised preferred alternative (*Preferred Remedial Alternative (Revised) Technical Memorandum,* December 3, 2004). This Final FS incorporates BNSF's revised preferred alternative and responds to Ecology's comments on that alternative.

Ecology will evaluate all the alternatives presented in this document and select a final cleanup action by balancing several factors, including the restoration time frame, degree of permanence (including cost), and adverse impacts to the community and natural environment. In general, more aggressive technologies cost more, work faster, and are more permanent, but they have greater adverse impacts on the community and natural environment. BNSF believes that its revised preferred alternative, as presented in this document, achieves a reasonable balance between regulatory requirements and the goals and concerns expressed by the community.

Site Background

The former railway maintenance and fueling facility in the east King County town of Skykomish is now owned and operated by BNSF Railway Company (BNSF). Historical activities since the facility opened in the late 1890s included refueling and maintaining locomotives and operating an electrical substation for electric engines. These activities released contaminants to the surrounding environment. BNSF has accepted responsibility for cleaning this historical contamination at the site consistent with the Model Toxics Control Act (MTCA) and the State Environmental Policy Act (SEPA).

Fuel was stored in above and underground storage tanks at the site until 1974, when BNSF discontinued most fuel handling activities at its Skykomish facility. The BNSF facility is currently used as a base of operations for track maintenance and snow removal crews.

Railroad Avenue separates BNSF property from the main commercial district of the town. Maloney Creek flows south of BNSF property and west to the South Fork of the Skykomish River. The site encompasses an area of about 40 acres and includes BNSF property and adjacent property. The approximate boundaries of the study area are as follows: the South Fork Skykomish River to the north, approximately the Old Cascade Highway to the south, Maloney Creek to the west, and Skykomish city limits to the east.

In early 1991, Washington Department of Ecology (Ecology) designated the former maintenance and fueling facility as a high priority cleanup site. Later that year, BNSF indicated a desire to initiate a Remedial Investigation/Feasibility Study (RI/FS) in accordance with MTCA. At that time, formal negotiations for a legal agreement (called an Agreed Order) were initiated. Negotiations were completed in mid-1993. Following a public comment period, the Agreed Order, which includes detailed work plans for the RI/FS process and early interim cleanup work, was signed by Ecology and BNSF. BNSF and Ecology signed a separate agreed order in 2001 for additional interim cleanup work near the South Fork Skykomish River and the levee west of Fifth Street.

Historic and Cultural Resources

Much of the Town of Skykomish has been designated in the National Register of Historic Places, including 13 historic buildings and the Skykomish Bridge. Several of the cleanup alternatives require moving historic buildings temporarily to allow for excavation beneath them. The buildings would then be returned to their original sites in such a way that the rail-oriented configuration of lots and buildings, streetscape and location of buildings relative to the street are maintained. Potential impacts to historic resources may result from temporary relocation, such as loss of landscape features, movement or settling of buildings, and some changes of surface grade. These impacts are discussed in the Draft FS and Draft EIS and will be further addressed, including any necessary mitigation measures, in the Final EIS consistent with SEPA.

Site Contaminants

Investigations performed by BNSF in cooperation with Ecology since 1993 have revealed petroleum contamination in soil, groundwater, the River and the former Maloney Creek that exceeds state standards. The contamination has migrated beyond the railroad property and has been found underneath homes and businesses in Skykomish and in “seeps” on the banks of the South Fork

Skykomish River. In addition, the investigation found lead and arsenic in soils to a depth of approximately six inches.

Based on available data, the site contamination consists of the following:

- **Soils –** Surface soils on the railyard contain petroleum (diesel and bunker C), lead and arsenic above state cleanup standards. Lead and arsenic was also found above cleanup standards in surface soils off BNSF property, but the source of these contaminants is unknown. In some areas of the site, including areas off the railyard, subsurface soils contain petroleum and its components (e.g., polynuclear aromatic hydrocarbons or PAHs) to an approximate 15-foot depth. PCBs have also been detected within the railyard at low concentrations, and are a continued source of concern for the public.

- **Groundwater –** Mixtures of both floating and dissolved diesel and bunker C are present in groundwater beneath the site at levels greater than allowed under state law.

- **Surface Water –** Diesel and bunker C from upland areas are seeping into the river after being transported underground by groundwater.

- **Sediments –** Diesel and bunker C from upland areas are present in sediments along the riverbank at seep locations and below the former Maloney Creek channel.

Cleanup Process

BNSF and Ecology have been working with the local community to ensure all exposure pathways are evaluated and the site is cleaned up. One theme from comments received is that the cleanup should be completed as quickly as possible while preserving historic structures/buildings and public facilities and minimizing disruption of residents and businesses. The contaminants are known to be toxic above certain concentrations, and some components are known human carcinogens. The material seeping into the South Fork Skykomish River and floating on the groundwater north of the railyard are primary concerns because these are areas in which significant exposure is more likely. Although the seep contamination poses little immediate risk to human health, cleanup is necessary to minimize any long-term risk and improve the overall environmental health of the Town of Skykomish and the South Fork Skykomish River. Cleanup actions will include activities to stop contaminants from seeping into the River.

BNSF is currently working with Ecology towards implementing a cleanup action on the levee and in the South Fork Skykomish River in 2006. This action would consist of excavating and replacing the flood control levee, excavating contaminated sediment and the underlying sand and gravel adjacent to the levee and in the Skykomish River, and installing an air sparging system within the levee to treat groundwater discharging into the river. Additional details are presented in Section 10.2.

Additional Interim Action to Address Seeps to the River in 2001

BNSF enhanced its product recovery system to stop contaminants from seeping into the South Fork Skykomish River at the levee through an Interim Action during 2001. An Interim Action is any action that partially addresses the final cleanup of a site. The Interim Action in 2001 resulted in construction of an underground barrier wall west from the bridge along West River Road to stop seeps from reaching the River. Monitoring wells were installed behind (upgradient of) the wall and at the ends of the wall to determine where contaminants accumulate. Temporary recovery operations are conducted from these wells. During the second phase, the wells that contained the most petroleum product were converted into product recovery wells that currently skim petroleum from groundwater. Additional wells were later installed.

Remedial Investigation, Feasibility Study, and Environmental Impact Statement Reports

BNSF submitted a Remedial Investigation Report (RI) to Ecology in 1996, a Draft Feasibility Study in 1999, and a Supplemental RI Report in 2002. These studies provide baseline data about soil, groundwater, surface water, air and river sediments throughout the site that are being used to develop cleanup options that are physically, economically, socially and scientifically feasible.

Based on the findings of these studies, BNSF prepared a Preliminary Draft Feasibility Study to evaluate cleanup alternatives and the potential impacts of those alternatives on the Skykomish site. That document was integrated with a Draft Environmental Impact Statement (June 13, 2003) consistent with SEPA. The Preliminary Draft FS and Draft EIS were revised based on comments from Ecology and in September 2003 the Draft FS and Draft EIS, along with the 1996 Remedial Investigation report and 2002 Supplemental RI report, were released by Ecology for public review and comment. BNSF considered the public comments in preparing this Final FS. Ecology will carefully consider the public comments when it prepares the Draft Cleanup Action Plan (DCAP) and Final EIS.

Draft Cleanup Action Plan

The DCAP will outline the work to be performed during the actual cleanup of the site and additional public comments will be solicited. Once comments are received and reviewed and any necessary changes are made to the DCAP, BNSF and Ecology will negotiate a consent decree to implement the Final CAP. The Final CAP will be an exhibit to the Consent Decree. The Consent Decree is a legal agreement between Ecology and BNSF that establishes their rights and obligations with respect to the Final CAP. The Final CAP will contain cleanup details, cleanup levels and points of compliance where BNSF must achieve cleanup. The Cleanup Action Plan and the consent decree will also be available for public comment before they are signed by Ecology.

Cleanup Zones

One of the first steps in developing the remedial alternatives was to divide the site into cleanup zones based on land use (railyard, commercial, residential), land type (wetland, levee, upland), exposure pathways, and distribution and chemical composition of the hazardous substances. The cleanup zones are described below.

1) Aquatic Resource Zones
    - South Fork Skykomish River and Levee
    - Former Maloney Creek channel
2) Developed Zones (land that has been or will likely be developed for commercial or residential use)
    - Northwest (NW) – affected by petroleum plume composed of diesel and bunker C
    - South – affected by petroleum plume composed of diesel and bunker C
    - Northeast (NE) – affected by petroleum plume of which 75 percent or greater is diesel (less viscous, more soluble, more biodegradable)
3) Railyard Zone
    - BNSF property
    - Two small areas immediately adjacent to the yard that are contaminated with surface soil metals, one of which is also contaminated with surface and subsurface TPH.

For each suggested remedial alternative, technologies and approaches are described for each cleanup zone.

Cleanup Standards

Cleanup standards establish:

1) The cleanup level, which is the concentration of a hazardous substance that protects human health and the environment under specific exposure conditions
2) The location on the site where that cleanup level must be reached, called the point of compliance

3) Other regulatory requirements that apply due to the type of cleanup action and/or location of the site.

Cleanup levels and points of compliance are established for each type of contaminated media. At the site, there are four media with contamination: soil, sediments, surface water, and groundwater.

For all remedial alternatives presented in this Final FS, the points of compliance are the same for soils, sediments, and surface water. However, three different points of compliance have been developed for groundwater.

Groundwater Points of Compliance:

1) **Standard Point of Compliance –** Groundwater must meet cleanup levels throughout the site, from the uppermost level of the saturated zone and extending to the lower-most depth that could potentially be affected by the site.

2) **Conditional Point of Compliance, On-Property –** Groundwater must meet cleanup levels at the BNSF property boundary.

3) **Conditional Point of Compliance, Off-Property –** Groundwater must meet cleanup levels at the point it discharges to the South Fork Skykomish River and the former Maloney Creek channel, or as close as practicable to the source. (Note: affected property owners between BNSF's property boundary and the South Fork Skykomish River must agree in writing to setting this conditional point of compliance.)

Institutional Controls

Institutional controls are part of the cleanup action alternatives in the Final FS. Institutional controls are legal or administrative measures designed to limit or control activities that could result in exposures. They are particularly used in situations where contaminant residues are likely to remain above cleanup levels for an extended period of time. A Restrictive Covenant is one common type of institutional control; it limits or restricts the use of a property and is binding for all current and future owners of the property. Another common institutional control is a local ordinance or state regulation that limits installation of groundwater wells or requires special permits before excavation or drilling in contaminated soil. For example, the Town of Skykomish can, by ordinance, limit installation of groundwater wells where public water is already available. Ecology can adopt similar regulations.

Some type of institutional controls will be required for each alternative, including the "Standard" alternative, to ensure protection from residual contaminated soil and groundwater while BNSF works to achieve Ecology's cleanup standards.

Remedial Alternatives

The site-wide remedial alternatives were developed to meet the cleanup standards for the three groundwater points of compliance described above. The Standard alternative uses the standard groundwater point of compliance described above. The PB, or BNSF Property Boundary, alternatives (PB1 through PB5) use the on-property groundwater point of compliance, while the SW, or Surface Water, alternatives (SW1 through SW4) use the off-property groundwater point of compliance. In addition, a No Action alternative is evaluated for comparison. Finally, BNSF has presented a "preferred" remedial alternative which includes a conditional point of compliance for groundwater similar to SW.

Individual technologies were selected for each cleanup zone and then combined based on their ability to comply with cleanup standards and attain remediation levels.

Each alternative in this Final FS can achieve cleanup standards and protect public health and the environment. Selecting a cleanup action from among the alternatives requires balancing several additional factors, including the restoration time frame, degree of permanence (including cost), and adverse impacts to the built and natural environment. In general, more aggressive technologies cost more, work faster, and are more permanent, but they have greater adverse impacts on the built and natural environment. The following remedial alternatives are named according to point of compliance where the cleanup levels would be attained.

- **STD (Standard) Alternative –** The Standard alternative meets cleanup levels at standard points of compliance throughout the site for all media. As such, the Standard alternative represents the most permanent alternative. All free product and contaminated soil and sediment will be removed. Groundwater will eventually be restored to levels that are protective of all risk pathways (including recontamination of sediments) through natural attenuation after free product and contaminated soil is excavated. Long-term maintenance or inspection is not required. The Standard alternative relies on excavation of all free product, all impacted soil, and all sediment above cleanup levels. All contamination above cleanup levels would be removed from the sediment in the bed and banks of the South Fork Skykomish River and former channel of Maloney Creek would be restored, the levee would be excavated and rebuilt, and structures, roads and utilities would be removed, replaced or rebuilt. Institutional controls would limit exposure until monitoring shows that groundwater achieves cleanup standards.

- **PB (Property Boundary) Alternatives** – The PB alternatives meet cleanup standards for groundwater at an on-property, conditional groundwater point of compliance at the railyard property boundary. This means that groundwater must be clean at the BNSF property boundary. All free product will be removed, petroleum discharges to the River will be eliminated, surface soil metals contamination will be removed and groundwater between the railyard and River will be restored to levels protective of the environment and human health. Subsurface soil on and off the railyard and groundwater on the railyard will continue to exceed cleanup levels. Protection from this material will be achieved through containment, institutional controls, and a long-term maintenance, inspection and monitoring program.

- **SW (Surface Water) Alternatives –** The SW alternatives meet cleanup standards for groundwater at an off-property, conditional groundwater point of compliance. In other words, groundwater must be clean before it discharges into the South Fork Skykomish River and former Maloney Creek channel or as close to the source as practicable. The SW alternatives will improve groundwater at the site but will not meet groundwater or soil cleanup levels on BNSF property or on properties between the BNSF property and the River. All free product will be removed, petroleum discharges to the River will be eliminated, and surface soil metals contamination will be excavated. Subsurface soil contamination of the railyard and areas between the railyard and the River will continue to exceed cleanup levels. Protection is achieved in areas where soil or groundwater exceed cleanup levels through a protective soil cap, institutional controls, and a long-term maintenance and monitoring program.

- **BNSF's Preferred Alternative –** BNSF's preferred alternative meets cleanup standards for groundwater at a conditional point of compliance, similar to the SW alternatives. All free product will be removed, petroleum discharges to the River will be eliminated, surface soil metals contamination will be removed and groundwater discharging to the River will be restored to levels protective of environmental and human health. Subsurface soil on and off the railyard and groundwater on the railyard and areas between the railyard and the River will continue to exceed cleanup levels. Protection from this material will be achieved through containment, institutional controls, and a long-term maintenance, inspection and monitoring program.

Summary of Preferred Alternative

The preferred alternative consists of the following cleanup activities in the different cleanup zones.

1) **Levee –** excavate and rebuild portions of the levee to remove free product and contaminated soil and excavate surface sediment along and within the South Fork Skykomish River at the base of the levee. Treatment of groundwater beneath the levee using biological treatment as a contingency if necessary to achieve cleanup levels.

2) **Former Maloney Creek Channel –** treat groundwater using enhanced bioremediation and limited soil excavation

3) **NE Developed Zone –** enhanced biological treatment of soil and groundwater, and limited soil excavation

4) **South Developed Zone –** soil excavation

5) **Railyard Zone –** excavate upper 2 feet of metals-impacted soil and recover free product using interceptor trenches

6) **NW Developed Zone –** excavate metals impacted soil in the upper two feet, excavate free product and contaminated soil within 135 feet of the river, and construct trenches to recover free product and prevent free product migration into excavated areas.

Remediation Levels

All of the remedial alternatives, except for the Standard Alternative, will use remediation levels to define the extent to which different components of a remedial alternative will be applied as part of the overall cleanup action that achieves cleanup standards.

Remediation levels may be used at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance. Remediation levels may also be used at sites where the cleanup action involves the containment of soils. Remediation levels are not the same as cleanup levels. A cleanup level defines the concentration of hazardous substances above which a contaminated medium (e.g., soil) must be remediated in some manner (e.g., treatment, containment, institutional controls). A remediation level, on the other hand, defines the concentration (or other method of identification such as depth, location, etc.) of a hazardous substance in a particular medium above or below which a particular component of a cleanup action (e.g., soil excavation or containment) will be used.

The remediation levels that have been applied to various cleanup alternatives in the FS consist of the following:

1) Free product removal

2) Free product removal, where accessible

3) Soil treatment to 20,000 mg/kg petroleum (by NWTPH-Dx)

4) Soil treatment to 3,400 mg/kg petroleum (by NWTPH-Dx) to protect against direct contact exposure

5) Soil treatment to 2,000 mg/kg petroleum (by NWTPH-Dx)

6) Surface sediment removal with minimal damage to wetland vegetation.

Estimated Cost of Remedial Alternatives

The total costs for each alternative are as follows:

Remedial Alternative	Total Cost
BNSF's Preferred Alternative	$20,700,000
SW1	$5,800,000
SW2	$10,600,000
SW3	$14,700,000
SW4	$23,300,000
PB1	$14,000,000
PB2	$20,300,000
PB3	$24,600,000
PB4	$37,000,000
PB5	$57,100,000
Standard	$87,700,000

The most expensive elements of cleanup are the NW Developed Zone, the levee, and the railyard. In general, cost increases as the amount of contaminated material removed increases. The degree of permanence of the alternative is also considered. This correlates with the amount of material removed, and thus cost as well. The "cost effectiveness" of each remedial alternative can be approximated by comparing cost per soil removal volumes

Since a high level of protection can be achieved by all remedial alternatives, the key differences influencing decisions on a remedial alternative are permanence, restoration time frame and adverse impacts on the built and natural environment.

Restoration Time Frames

This Final FS presents the time frames estimated for removal of free product, restoration of groundwater to cleanup levels at the point of compliance, and restoration of soil to cleanup levels at the point of compliance, respectively. For each media addressed, the figures show time frame per cleanup zone.

Free product will be removed from all off-railyard areas within 10 years for alternatives SW4, PB2, PB3, PB4, PB5 and STD. Free product will be removed from all off-railyard areas within two years for the preferred alternative, except for the NW Developed Zone. Free product will remain on the railyard for greater than 30 years for most alternatives, except PB5 and STD that remove free product within a couple of years. All but four alternatives achieve cleanup standards for groundwater within 10 years. This restoration timeframe reflects the different groundwater points of compliance between the SW and PB alternatives. Only two alternatives achieve soil cleanup levels within 10 years and this assumes that an empirical demonstration will be successful for PB5. Eight of the alternatives achieve soil cleanup levels in all off-railyard zones, except the Northwest Developed Zone, within 20 years. PB4, PB5, STD and the preferred alternative reduce the restoration time frame to less than 10 years for these same zones.

Selecting a Final Remedial Alternative

This Final FS describes the minimum and "other" requirements for selecting a final remedy consistent with MTCA. Although BNSF has indicated its preferred alternative in this Final FS, Ecology makes the final selection of cleanup actions when it issues a CAP. Each alternative cleanup action developed in a feasibility study must satisfy the minimum MTCA threshold requirements. These requirements are (1) Protect human health and the environment; (2) comply with cleanup standards; (3) comply with applicable state and federal laws; (4) provide for compliance monitoring.

When selecting from among the cleanup action alternatives that satisfy threshold requirements, Ecology also considers the following additional criteria from MTCA: (1) use permanent solutions to the maximum extent practicable; (2) provide for a reasonable restoration timeframe; and, (3) public and agency comments and concerns. This Final FS provides information to Ecology to select a final remedial alternative at Skykomish consistent with MTCA. Ecology also considers probable, significant adverse environmental impacts and reasonable measures to mitigate those impacts and the Draft EIS and Final EIS provide information to Ecology to select a final remedy consistent with the State Environmental Policy Act (SEPA).

Table of Contents

1 Introduction 1-1
1.1 Purpose and Objectives 1-1

2 Background 2-1
2.1 Town and Site Description and History 2-1
2.1.1 Town Description 2-1
2.1.2 Site Description 2-2
2.1.3 Railyard Operational History 2-4
2.2 Natural Environment 2-6
2.2.1 Earth 2-6
2.2.2 Water 2-11
2.2.3 Air 2-19
2.2.4 Plants 2-20
2.2.5 Wildlife 2-24
2.2.6 Fish and Aquatic Biota 2-31
2.3 Built Environment 2-37
2.3.1 Land and Shoreline Use Plans 2-37
2.3.2 Historical and Cultural Resources 2-39
2.3.3 Public Services 2-40
2.3.4 Environmental Health 2-41
2.3.5 Transportation 2-42
2.4 Interim Cleanup Actions and Ongoing Site Maintenance 2-43
2.4.1 Barrier System 2-43
2.4.2 Oil Recovery Booms 2-44
2.4.3 Dust Suppression Application 2-44

3 Nature and Extent of Contamination 3-1
3.1 Soil Quality 3-2
3.1.1 Petroleum Hydrocarbons in Soil 3-4
3.1.2 Metals in Soil 3-7
3.1.3 Polychlorinated Biphenyls in Soil 3-7
3.2 Free Product 3-8
3.2.1 Physical Properties of Free Product 3-8
3.2.2 Location and Extent of Free Product 3-9
3.3 Groundwater Quality 3-11
3.3.1 Petroleum Hydrocarbons in Groundwater 3-11
3.4 Sediment Quality 3-14
3.4.1 South Fork Skykomish River Sediment 3-14
3.4.2 Former Maloney Creek Sediment 3-14
3.5 Surface Water Quality 3-17
3.6 Air Quality 3-18
3.7 Summary of the Nature and Extent of Contamination 3-19
3.8 Indicator Hazardous Substances 3-21

Table of Contents

4 Conceptual Site Model 4-1
4.1 Source Characterization 4-1
4.2 Indicator Hazardous Substances and Impacted Media 4-2
4.2.1 Metals 4-2
4.2.2 Petroleum Hydrocarbons 4-3
4.3 Conceptual Model Summary 4-7
4.4 Exposure Assessment 4-8
4.4.1 Current and Potential Land and Resource Uses 4-8
4.4.2 Potential Receptors 4-12
4.4.3 Transport Mechanisms 4-14
4.4.4 Potential Receptor Exposures 4-15
4.5 Summary 4-16
4.5.1 Soil 4-16
4.5.2 Groundwater 4-17
4.5.3 Sediment 4-17
4.5.4 Surface Water 4-17

5 Cleanup Standards 5-1
5.1 Indicator Hazardous Substances 5-1
5.2 Cleanup Levels 5-2
5.2.1 Soil 5-3
5.2.2 Groundwater 5-7
5.2.3 Sediment 5-9
5.2.4 Surface Water 5-10
5.3 Points of Compliance 5-12
5.3.1 Soil 5-13
5.3.2 Groundwater 5-13
5.3.3 Sediment 5-15
5.3.4 Surface Water 5-15
5.3.5 Air 5-15
5.4 Other Potentially Applicable Requirements 5-15

6 Remediation Levels 6-1
6.1 Introduction 6-1
6.2 Remediation Levels for Soil 6-2
6.2.1 Remove Free Product 6-2
6.2.2 Excavate Free Product Where Accessible 6-4
6.2.3 Remove/Treat Soil to 20,000 mg/kg NWTPH-Dx 6-5
6.2.4 Remove Soil to 2,000 mg/kg NWTPH-Dx 6-5
6.2.5 Direct Contact (Human) 6-6
6.2.6 Terrestrial Ecological Exposure 6-7
6.2.7 Soil to Air 6-8

7 Development of Remedial Alternatives 7-1
7.1 Technology Screening 7-1

Table of Contents

7.1.1 Metals in Soil ... 7-1
7.1.2 Petroleum Hydrocarbons in Soil ... 7-2
7.1.3 LNAPL ... 7-2
7.1.4 Dissolved Petroleum Hydrocarbons in Groundwater ... 7-2
7.2 Bench-Scale Testing of Cleanup Technologies ... 7-2
7.2.1 Results for Flushing with Surfactant and Polymer ... 7-3
7.2.2 Results for Biological Treatment ... 7-4
7.2.3 Summary of Bench-Scale Results for Chemical Oxidation with Ozone ... 7-5
7.3 Approach to Developing Remedial Alternatives ... 7-6
7.3.1 Site Cleanup Zones ... 7-6
7.3.2 Points of Compliance ... 7-7
7.4 Description of Remedial Alternatives ... 7-8
7.4.1 Detailed Description of Remedial Approaches by Cleanup Zone ... 7-8
7.4.2 Description of Site-Wide Remedial Alternatives ... 7-28

8 MTCA Evaluation of Remedial Alternatives ... 8-1
8.1 Requirements for Remedial Alternatives ... 8-1
8.1.1 Threshold Requirements ... 8-1
8.1.2 “Other Requirements” ... 8-3
8.2 No Action Alternative ... 8-5
8.3 Evaluation of Alternative SW1 ... 8-5
8.4 Evaluation of Alternative SW2 ... 8-6
8.5 Evaluation of Alternative SW3 ... 8-8
8.6 Evaluation of Alternative SW4 ... 8-9
8.7 Evaluation of Alternative PB1 ... 8-10
8.8 Evaluation of Alternative PB2 ... 8-11
8.9 Evaluation of Alternative PB3 ... 8-13
8.10 Evaluation of Alternative PB4 ... 8-14
8.11 Evaluation of Alternative PB5 ... 8-15
8.12 Evaluation of Standard Alternative (STD) ... 8-16
8.13 Summary of Remedial Alternatives Evaluation ... 8-17
8.13.1 No Action ... 8-17
8.13.2 Standard Alternative ... 8-17
8.13.3 SW Alternatives ... 8-18
8.13.4 PB Alternatives ... 8-19

9 MTCA Remedial Alternative Selection Process ... 9-1
9.1 Threshold Requirements ... 9-1
9.1.1 Protect Human Health and the Environment ... 9-1
9.1.2 Comply With Cleanup Standards ... 9-4
9.1.3 Comply With Applicable Local, State and Federal Laws ... 9-5
9.1.4 Provide for Compliance Monitoring ... 9-6
9.2 Use Permanent Solutions to the Maximum Extent Practicable ... 9-6

Table of Contents

9.2.1 Protectiveness ... 9-6
9.2.2 Permanence ... 9-7
9.2.3 Cost ... 9-7
9.2.4 Effectiveness over the Long-Term ... 9-8
9.2.5 Management of Short-Term Risks ... 9-9
9.2.6 Technical and Administrative Implementability ... 9-9
9.2.7 Consideration of Public Concerns ... 9-10
9.2.8 Permanence to the Maximum Extent Summary ... 9-10
9.3 Provide for a Reasonable Restoration Timeframe ... 9-12
9.4 Consider Public Concerns ... 9-13
9.5 SEPA Analysis ... 9-14
9.6 Preferred Alternative Selection ... 9-14

10 Preferred Remedial Alternative ... 10-1
10.1 Factors Influencing Selection ... 10-2
10.2 Description of Preferred Alternative ... 10-3
10.2.1 Levee Aquatic Resource Zone ... 10-4
10.2.2 Former Maloney Creek Channel Aquatic Resource Zone ... 10-6
10.2.3 Northeast Developed Zone ... 10-8
10.2.4 South Developed Zone ... 10-9
10.2.5 Railyard Zone ... 10-10
10.2.6 Northwest Developed Zone ... 10-11
10.3 Project Schedule and Phasing ... 10-13
10.3.1 Remedial Design ... 10-14
10.4 Regulatory Evaluation of Alternative ... 10-14
10.4.1 Threshold Requirements ... 10-15
10.4.2 Use Permanent Solutions to the Maximum Extent Practicable ... 10-19
10.4.3 Provide for a Reasonable Restoration Timeframe ... 10-25
10.4.4 Consider Public Concerns ... 10-27
10.4.5 MTCA Site-Specific Requirements ... 10-27
10.4.6 SEPA ... 10-30
10.4.7 Preferred Alternative Selection ... 10-31
10.5 Compliance Monitoring Plan ... 10-31
10.5.1 Compliance with Cleanup Standards ... 10-32
10.5.2 Compliance with Remediation Levels ... 10-32
10.5.3 Contingent Actions ... 10-36
10.6 Financial Assurance ... 10-36

11 References ... 11-1

List of Tables

Table 2-1	South Fork Skykomish River Measurements
Table 2-2	Occurrence of Federal Threatened and Endangered Species in the Site Vicinity
Table 2-3	Salmonid Presence and Timing Within the South Fork and Former Maloney Creek Channel
Table 2-4	Typical Sound Levels Measured in the Environment and Industry
Table 3-1	Potentiometric Surface Elevations for Selected Wells – December 2002 to March 2003
Table 3-2	Petroleum Hydrocarbon Concentrations in Groundwater – January 2002 and January 2003
Table 3-3	PAH Concentrations in Groundwater
Table 3-4	BTEX Concentrations in Groundwater
Table 3-5	Summary of Final Indicator Hazardous Substances
Table 4-1	Indicator Hazardous Substances and Media
Table 4-2	Selected Physical Properties of Skykomish LNAPL Samples
Table 5-1	Proposed Cleanup Levels
Table 5-2	Potentially Applicable Requirements – Cleanup Levels
Table 5-3	Potentially Applicable Requirements – Treatment and Disposal
Table 5-4	Potentially Applicable Requirements – Other Remediation Activities
Table 6-1	Remediation Levels
Table 7-1	Technologies Identified and Screened for Use in Developing Remedial Alternatives
Table 7-2	Points of Compliance for Site Media
Table 7-3	Remedial Alternative Points of Compliance and Remediation Levels
Table 7-4	Remedial Alternatives Matrix
Table 7-5	Summary Description of Remedial Alternatives
Table 8-1	Remedial Alternatives and Cleanup Standards
Table 8-2	MTCA “Other Requirements”
Table 8-3	Summary Costs of Remedial Alternatives
Table 9-1	Benefit Analysis for Disproportionate Cost Analysis
Table 10-1	Benefit Analysis for Disproportionate Cost Analysis

List of Figures

Figure 1-1 Regional Location Map
Figure 1-2 BNSF Skykomish Path Forward
Figure 1-3 Steps to Site Cleanup Under MTCA
Figure 1-4 Block Flow Diagram of MTCA Feasibility Study

Figure 2-1 General Site Layout and Site Boundary
Figure 2-2 Sites of Demolished Railroad Buildings and Structures
Figure 2-3 Geologic Cross-Section W-E
Figure 2-4 Shoreline Hydrocarbon Seeps
Figure 2-5 Conceptual Site Model for Former Maloney Creek Channel
Figure 2-6 Topography of Area South of the River
Figure 2-7 Maloney Creek Catchment Area
Figure 2-8 Skykomish Stormwater Flow
Figure 2-9 FEMA 100- and 500-Year Flood Boundaries
Figure 2-10 Hydrographs of 2A-W-1 and 1A-W3
Figure 2-11 Groundwater Surface Elevation Map – 01/31/02 and 02/01/02
Figure 2-12 Habitat Types and Land Cover
Figure 2-13 Western End of Former Maloney Creek Wetland, North of Channel – December 2002
Figure 2-14 Western End of Former Maloney Creek Wetland, South of Channel – December 2002
Figure 2-15 Upstream End of Former Maloney Creek Channel – March 2003
Figure 2-16 Zoning and Land Use Areas
Figure 2-17 Historic Resources
Figure 2-18 A-Weighted Noise Level (dB) at 50 Feet
Figure 2-19 Location of the Subsurface Barrier Wall and Product Recovery System

Figure 3-1 Extent of Free Product
Figure 3-2 Site Cleanup Zones
Figure 3-3 TPH-Dx Distribution in Vadose Zone Soil
Figure 3-4 Interpolated TPH-Dx Distributed in Smear Zone Soil
Figure 3-5 Interpolated TPH-Dx Distributed in Saturated Zone Soil
Figure 3-6 Comparison of Soil TPH by NWTPH-Dx and Sum of EPH/VPH Fractions

List of Figures

Figure 3-7 Arsenic in Surface Soil
Figure 3-8 Lead in Surface Soil
Figure 3-9 PCBs in Soil
Figure 3-10 Product Thickness and Fluid Level Elevation versus Time: MW-36
Figure 3-11 Free Product and Dissolved TPH-Diesel in Groundwater
Figure 3-12 Sum of EPH and VPH and Sum of TPH
Figure 3-13 Extent of TPH Throughout Site
Figure 3-14 Extent of TPH in Former Maloney Creek Area

Figure 4-1 Conceptual Model of LNAPL Occurrence
Figure 4-2 Schematic Cross-Section Through Free Product Plumes
Figure 4-3 Exposure Pathway Conceptual Model

Figure 5-1 Approach to Setting Method B Cleanup Levels

Figure 6-1 Maximum Extent of Levee Remediation Excavation

Figure 7-1 Site Cleanup Zones
Figure 7-2 Basis for Areal Definition of Site Cleanup Zones
Figure 7-3 Levee Surface Sediment Removal Area
Figure 7-4 Levee Enhanced Bioremediation System Layout
Figure 7-5 Levee Estimated Extent of Excavation
Figure 7-6 Former Maloney Creek Channel Surface Sediment Removal Area
Figure 7-7 Former Maloney Creek Channel Enhanced Bioremediation System Layout
Figure 7-8 Former Maloney Creek Channel Estimated Extent of Excavations
Figure 7-9 NE Developed Zone Enhanced Bioremediation System Layouts
Figure 7-10 NE Developed Zone Estimated Extent of Excavations
Figure 7-11 South Developed Zone Estimated Extent of Excavations
Figure 7-12 NW Developed Zone Estimated Extent of Surface Metals Excavations
Figure 7-13 NW Developed Zone Free Product Recovery Trench Locations
Figure 7-14 NW Developed Zone Enhanced Bioremediation System Layouts
Figure 7-15 NW Developed Zone Estimated Extent of Excavations
Figure 7-16 Railyard Estimated Extent of Surface Soil Excavations

List of Figures

Figure 7-17 Railyard Free Product Recovery Trench Locations
Figure 7-18 Railyard Enhanced Bioremediation System Layout
Figure 7-19 Railyard Estimated Extent of Excavations
Figure 7-20 Site-Wide Remedial Alternative SW1 Layout
Figure 7-21 Site-Wide Remedial Alternative SW2 Layout
Figure 7-22 Site-Wide Remedial Alternative SW3 Layout
Figure 7-23 Site-Wide Remedial Alternative SW4 Layout
Figure 7-24 Site-Wide Remedial Alternative PB1 Layout
Figure 7-25 Site-Wide Remedial Alternative PB2 Layout
Figure 7-26 Site-Wide Remedial Alternative PB3 Layout
Figure 7-27 Site-Wide Remedial Alternative PB4 Layout
Figure 7-28 Site-Wide Remedial Alternative PB5 Layout
Figure 7-29 Site-Wide Remedial Alternative STD Layout

Figure 8-1 TPH Left On-Site After Active Remediation SW1
Figure 8-2 TPH Left On-Site After Active Remediation SW2
Figure 8-3 TPH Left On-Site After Active Remediation SW3
Figure 8-4 TPH Left On-Site After Active Remediation SW4
Figure 8-5 TPH Left On-Site After Active Remediation PB1
Figure 8-6 TPH Left On-Site After Active Remediation PB2
Figure 8-7 TPH Left On-Site After Active Remediation PB3
Figure 8-8 TPH Left On-Site After Active Remediation PB4
Figure 8-9 TPH Left On-Site After Active Remediation PB5
Figure 8-10 TPH Left On-Site After Active Remediation STD

Figure 9-1 Remedial Alternatives Ranked by Permanence
Figure 9-2 Remedial Alternative Costs by Permanence
Figure 9-3 Unit Equivalent Soil Removal Cost by Permanence
Figure 9-4 Benefit and Cost by Remedial Alternative Ranked by Permanence
Figure 9-5 Benefit vs. Cost
Figure 9-6 Incremental Benefit versus Cost Savings Relative to STD
Figure 9-7 Free Product Removal Timeframe
Figure 9-8 Groundwater Restoration Timeframe

List of Figures

Figure 9-9 Soil Restoration Timeframe

Figure 10-1 Preferred Remedial Alternative

Figure 10-2 Remedial Alternatives Ranked by Permanence

Figure 10-3 Remedial Alternative Costs by Permanence

Figure 10-4 Unit Equivalent Soil Removal Cost by Permanence

Figure 10-5 Benefit and Cost by Remedial Alternative Ranked by Permanence

Figure 10-6 Benefit vs. Cost

Figure 10-7 Incremental Benefit versus Cost Savings Relative to STD

Figure 10-8 Free Product Removal Timeframe

Figure 10-9 Groundwater Restoration Timeframe

Figure 10-10 Soil Restoration Timeframe

Figure 10-11 TPH Left On-Site After Active Remediation – Preferred Remedial Alternative

List of Appendices

Appendix A Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels

- Appendix A-1 Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels (February 24, 2003)
- Appendix A-2 Second Supplemental Sediment Sampling Results (November 20, 2003

Appendix B Wetland Detailed Study

Appendix C Skykomish Sanborn Map – 1926

Appendix D Terrestrial Ecological Evaluation

Appendix E Re-Reported NWTPH-Dx Groundwater Data

Appendix F Ecology Supplemental Sampling Logs and Data

Appendix G Selection of Indicator Hazardous Substances

Appendix H Technical Memo No. 1 (Revision 1) – EPH/VPH Data Set for Skykomish Site (September 6, 2002)

Appendix I Technical Memo 2 – Site-Specific Input Parameters for TPH Four Phase Model (November 22, 2002) and Related F_{oc} Correspondence, Work Plans, Results and Ecology Approval

Appendix J Calculation of Surface Water CULs Protective of Human Health via Fish/Shellfish Consumption

Appendix K Groundwater Cleanup Levels for TPH Protective of Ecological Resources in Surface Water (January 17, 2003)

Appendix L Leach Testing and Response to Comments

- Appendix L-1 Report of Leach Testing to Derive Soil Cleanup Levels to Protect Groundwater (April 10, 2003)
- Appendix L-2 Response to Ecology Comments on Leach Testing

Appendix M Screening of Remedial Technologies

- Appendix M-1 Screening of Remedial Technologies
- Appendix M-2 Biodegradation Processes
- Appendix M-3 Geotechnical Shoring Analysis
- Appendix M-4 Air Monitoring Logs
- Appendix M-5 Additional Evaluation of Remedial Technologies

Appendix N Detailed Cost Estimates

Appendix O List of Potentially Affected Properties (Excluding Railyard)

List of Appendices

Appendix P Cost-Benefit Analysis

Appendix Q Restrictive Covenant

Appendix R Example Financial Assurance Documentation

Appendix S Fate and Transport Modeling

List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BMP	Best Management Practices
BNSF	BNSF Railway Company
BNRR	Burlington Northern Railroad
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTU	British Thermal Unit
CAO	Critical Areas Ordinance
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
cm/sec	centimeters per second
CO	carbon monoxide
cP	centipoise
cPAH	carcinogenic polynuclear aromatic hydrocarbon
CSM	Conceptual Site Model
CWA	Clean Water Act
cy	cubic yard
dB	decibel (measurement of noise volume)
dBA	decibels at equivalent A-weighted sound levels
dbh	diameter at breast height
DO	dissolved oxygen
DOD	United States Department of Defense
DOE	United States Department of Energy
dynes/cm	dynes per centimeter
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
EPH/VPH	extractable and volatile petroleum hydrocarbon fractions
f_{oc}	fraction of organic carbon

List of Acronyms

FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
FS/EIS	Feasibility Study and Environmental Impact Statement
ft^2	square feet
g/kg	grams per kilogram
GNR	Great Northern Railroad
gpm	gallons per minute
HDPE	high-density polyethylene
IHS	Indicator Hazardous Substances
LD50	lethal dose for 50 percent kill
LNAPL	light nonaqueous phase liquid
MACT	maximum acceptable concentration threshold
MCL	maximum contaminant level
MCLG	maximum contaminant level goal (formerly RMCL)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
msl	mean sea level
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NAPL	nonaqueous phase liquid
NMFS	National Marine and Fisheries Service
NO_x	nitrous oxides
NRWQC	National Recommended Water Quality Criteria
ORP	oxygen reduction potential
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
pH	measure of acidity or alkalinity
POC	point of compliance
Poise	A unit of [dynamic] viscosity. One poise is the viscosity of a liquid in which a force of one dyne is necessary to maintain a velocity

List of Acronyms

	differential of one centimeter per second per centimeter over a surface one. [Poise is a measure of absolute or dynamic viscosity.]
PPE	personal protective equipment
ppm	parts per million
PQL	practical quantitation level
PSCAA	Puget Sound Clean Air Agency
RCW	Revised Code of Washington
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
SAP	Sampling and Analysis Plan
scfm	standard cubic feet per minute
SDWA	Safe Drinking Water Act
SEPA	State Environmental Policy Act
site	BNSF Skykomish site
SMS	Sediment Management Standards
SOW	Scope of Work
Stokes	A unit of kinematic viscosity (dynamic viscosity divided by the density). In the SI system the accepted unit is square meter per second (m^2/s). To convert one stokes to (m^2/s) multiply by 1.0×10^{-4}.
SVOC	semivolatile organic compound
su	standard unit
TEE	terrestrial ecological evaluation
TOC	total organic carbon
TPH	total petroleum hydrocarbons
TPH-D	total petroleum hydrocarbons – diesel
TPH-Dx	total petroleum hydrocarbons – diesel extended
TPH-MO	total petroleum hydrocarbons – motor oil
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

List of Acronyms

USFS	United States Forest Service
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbon
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
WET	whole effluent toxicity
WSDOT	Washington State Department of Transportation
ºC	degrees Celsius
ºF	degrees Fahrenheit

List of MTCA Definitions

Free Product	[173-340200]	“a NAPL that is present in the soil…gw or sw as a distinct separate layer. Under the right conditions, if sufficient free product is present, free product is capable of migrating independent of the direction of flow of the gw or sw.”
NAPL	[---200]	“a hazardous substance that is present in the soil, groundwater, surface water as a liquid not dissolved in water. The term includes both LNAPL and DNAPL.”
Residual Saturation	[---747(10)(b)]	“When a NAPL is released to the soil, some of the NAPL will be held in the soil pores or void spaces by capillary force. …., the concentration of hazardous substances in the soil at equilibrium conditions is called residual saturation. At concentrations above residual saturation, the NAPL will continue to migrate due to gravimetric and capillary forces and may eventually reach the gw, provided a sufficient volume of NAPL is released.”

Glossary

Agreed Order: A legal document, issued by Ecology, which formalizes an agreement between Ecology and the potentially liable persons for the actions needed at a site. An Agreed Order may be used for all remedial actions except for non-routine cleanup actions and interim actions that constitute a substantial majority of a cleanup action likely to be selected. Since an Agreed Order is not a settlement, it shall not provide for mixed funding, a covenant not to sue, or protection from claims for contribution. An agreed order means that the potentially liable person agrees to perform remedial actions at the site in accordance with the provisions of the agreed order, and that Ecology will not take additional enforcement action against the potentially liable person to require those remedial actions specified in the agreed order, so long as the potentially liable person complies with the provisions of the order. Agreed orders are subject to public comment. If an order substantially changes, an additional public comment period is provided.

Built Environment: The elements of the environment that are generally built or made by people as contrasted with natural processes, including roads, utilities, buildings and bridges.

Cleanup: The implementation of a cleanup action or interim action.

Cleanup Action: Any remedial action, except interim actions, taken at a site to eliminate, render less toxic, stabilize, contain, immobilize, isolate, treat, destroy, or remove a hazardous substance that complies with cleanup levels; utilizes permanent solutions to the maximum extent practicable; and includes adequate monitoring to ensure the effectiveness of the cleanup action.

Cleanup Action Plan: A document that selects the cleanup action and specifies cleanup standards and other requirements for a particular site. The cleanup action plan, which follows the remedial investigation/feasibility study report, is subject to a public comment period. After completion of a comment period on the draft cleanup action plan, Ecology issues a final cleanup action plan.

Cleanup Level: The concentration of a hazardous substance in soil, water, air, or sediment that is determined to be protective of human health and the environment under specified exposure conditions.

Cleanup Process: The process for identifying, investigating, and cleaning up hazardous waste sites.

Consent Decree: A legal document, approved and issued by a court, which formalizes an agreement reached between Ecology and potentially liable persons on the actions needed at a site. A consent decree is subject to public comment, and a public meeting is required. If a consent decree substantially changes, an additional comment period is provided. After satisfying the public comment and meeting requirements, Ecology files the consent decree with the appropriate superior court or federal court having jurisdiction over the matter.

Containment: A container, vessel, barrier, or structure, whether natural or constructed, which confines a hazardous substance within a defined boundary and prevents or minimizes its release into the environment.

Contaminant: Any hazardous substance that does not occur naturally or occurs at greater than natural background levels.

Dissolved-Phase Contaminants: Chemicals that are constituents of LNAPL and have dissolved into groundwater over time (see also LNAPL).

Exposure Pathway: The path a hazardous substance takes or could take from a source to an exposed organism. An exposure pathway describes the mechanism by which an individual or population is exposed or has the potential to be exposed to hazardous substances at or originating from a site.

Feasibility Study (FS): Provides identification and analysis of site cleanup alternatives and is usually completed within a year. The entire Remedial Investigation/Feasibility Study (RI/FS) process takes about two years and is followed by the cleanup action plan. The purpose of the Remedial Investigation/Feasibility Study is to collect and develop sufficient site information regarding a site to enable the selection of a cleanup action.

Free Product: A hazardous substance that is present as a nonaqueous phase liquid (that is, liquid not dissolved in water). Free product flows and accumulates as a liquid separate from water in wells.

Groundwater: Water found beneath the earth’s surface that fills pores between materials such as sand, soil, or gravel. In aquifers, groundwater occurs in sufficient quantities that it can be used for drinking water, irrigation, and other purposes.

Hazardous Site List: A list of ranked sites that require further remedial action. These sites are published in the Site Register.

Interim Action: Any remedial action that partially addresses the cleanup of a site. It is an action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility; an action that corrects a problem that may become substantially worse or cost substantially more to address if the action is delayed; an action needed to provide for completion of a site hazard assessment, state remedial investigation/feasibility study, or design of a cleanup action.

Glossary

Light Non-Aqueous Phase Liquid (LNAPL): Liquid that is present as a separate phase from water, with a specific gravity less than one, that floats on groundwater and accumulates on top of water in wells, groundwater or surface water is called mobile (free-phase) LNAPL. See also residual LNAPL.

Model Toxics Control Act (MTCA): Refers to RCW 70.105D. Voters approved it in November 1988. The implementing regulation is WAC 173-340 and was amended in 2001.

Monitoring Wells: Special wells drilled at specific locations on or off a hazardous waste site where groundwater can be sampled at selected depths and studied to determine the direction of groundwater flow and the types and amounts of contaminants present.

Natural Environment: The elements of the environment frequently referred to as natural elements, or resources, such as earth, air, water and wildlife.

Polynuclear Aromatic Hydrocarbon (PAH): A class of organic compounds, common in some petroleum products, some of which are long lasting and carcinogenic. These compounds are formed from the combustion of organic material and are ubiquitous in the environment.

Public Notice: At a minimum, adequate notice mailed to all persons who have made a timely request of Ecology and to persons residing in the potentially affected vicinity of the proposed action; mailed to appropriate news media; published in the local (city or county) newspaper of largest circulation; and the opportunity for interested persons to comment.

Public Participation Plan: A plan prepared under the authority of WAC 173-340-600 to encourage coordinated and effective public involvement tailored to the public's needs at a particular site.

Recovery Wells: Special wells drilled at specific locations on or off a hazardous waste site where petroleum products can be recovered from the groundwater and recycled or disposed in accordance with state law and regulations.

Redd: A depression created in gravel beds by the upstroke of the female salmon's body and tail, used by spawning salmon to create "nests" for their eggs.

Release: Any intentional or unintentional entry of any hazardous substance into the environment.

Remedial Action: Any action to identify, eliminate, or minimize any threat posed by hazardous substances to human health or the environment, including any investigative and monitoring activities of any release or threatened release of a hazardous substance, and any health assessments or health effects studies conducted in order to determine the risk or potential risk to human health.

Remedial Investigation (RI): Any remedial action that provides information on the extent and magnitude of contamination at a site. This usually takes 12 to 18 months and is followed by the feasibility study. The purpose of the Remedial Investigation/Feasibility Study is to collect and develop sufficient site information regarding a site to enable the selection of a cleanup action.

Residual LNAPL: The oily residue that is caught up in the soil pores due to capillary pressure following the removal of mobile LNAPL (see LNAPL). Residual LNAPL can provide a continuous source of contamination to groundwater from soluble constituents.

Responsiveness Summary: A compilation of all questions and comments to a document open for public comment and their respective answers/replies by Ecology. The responsiveness summary is mailed, at a minimum, to those who provided comments, and its availability is published in the Site Register.

Risk: The probability that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans or other living organisms.

Risk Assessment: The determination of the probability that a hazardous substance, when released into the environment, will cause an adverse effect in exposed humans or other living organisms.

Seep: A point on the riverbank where the groundwater has carried the petroleum products and those products are released into the river.

Total Petroleum Hydrocarbons (TPH): A scientific measure of the sum of all petroleum hydrocarbons in a sample (without distinguishing one hydrocarbon from another). The "petroleum hydrocarbons" include compounds of carbon and hydrogen that are derived from naturally occurring petroleum sources or from manufactured petroleum products (such as refined oil, coal, and asphalt).

Toxicity: The degree to which a substance at a particular concentration is capable of causing harm to living organisms, including people, plants and animals.

1 Introduction

This report presents the Final Feasibility Study (FS) for BNSF's Former Maintenance and Fueling Facility located in Skykomish, Washington (site). Figure 1-1 shows the site boundary, which is not limited to BNSF's property. This Final FS evaluates alternatives for cleanup action at the Skykomish Site.

BNSF and Ecology released an integrated Draft Feasibility Study and Draft Environmental Impact Statement on September 3, 2003, for comment by the public and other regulatory agencies. After considering comments that BNSF and the agency received on the Draft FS and Draft EIS, BNSF developed a preliminary preferred alternative and included that in the Draft Final FS (RETEC, July 26, 2004). BNSF presented its preliminary preferred alternative to Ecology and the community, collected additional information from technology vendors, revised its preliminary preferred alternative and prepared a detailed description and analysis of the revised preferred alternative. *Preferred Remedial Alternative (Revised) Technical Memorandum* (December 3, 2004). This Final FS incorporates BNSF's revised preferred alternative and responds to Ecology's comments on that alternative.

Figure 1-2 presents a flowchart with the next procedural steps. This document is the Final FS. The Final FS will be followed by the Draft Cleanup Action Plan (DCAP) and then the Final CAP (FCAP) and Final EIS (FEIS). The public and other regulatory agencies will be invited to comment on the DCAP.

In 1993, the BNSF Railway (BNSF) entered into an Agreed Order (No. DE91TC-N213) (1993 Agreed Order) with the Washington State Department of Ecology (Ecology) to conduct a Remedial Investigation and Feasibility Study (RI/FS) and to implement certain interim cleanup actions. BNSF and Ecology entered into a second Agreed Order in 2001 (No. DE 01TCPNR-2800) under which BNSF implemented additional interim actions.

Cleanup of the site is being done under the authority of Chapter 70.105D Revised Code of Washington (RCW), *Hazardous Waste Cleanup – Model Toxics Control Act* (MTCA), and its implementing regulations, Chapter 173-340 Washington Administrative Code (WAC), *The Model Toxics Control Act Cleanup Regulation*. This statute and its implementing regulations apply to the site in their entirety and govern all remedial actions at the site.

1.1 Purpose and Objectives

The purpose of a Feasibility Study is to present and evaluate alternatives for a cleanup. The FS is used by Ecology to solicit public and agency comments and select a cleanup action for the site under WAC 173-340-360 through 173-340-390.

Figure 1-3 presents a general flow diagram of the MTCA process. This shows that the FS is one of several sequential requirements leading to site cleanup under MTCA. The FS uses data collected during the Remedial Investigation (RI) and additional data collected for the FS to develop and evaluate cleanup action alternatives. After the FS is complete, Ecology will issue a cleanup action plan (WAC 173-340-380); this plan will present the selected cleanup action(s) that will be used to address site contamination.

Figure 1-4 presents a diagram that summarizes the information presented in a Feasibility Study under MTCA. This information is presented in this FS for the BNSF Skykomish site. As shown on Figure 1-4, an FS uses general facility information, and data collected from field investigations. Some of the key elements of this FS are described below.

- **Indicator Hazardous Substance (IHS).** IHSs are typically a subset of substances that contribute the majority of the overall threat to human health and the environment. These are used to define site cleanup requirements and are defined in the FS.

- **Conceptual Site Model (CSM).** The CSM provides the nature and extent of contamination, fate and transport characteristics of the IHSs, current and potential contaminant migration pathways and receptors of site contamination, and current and potential land use and resources. The CSM is intended to further refine the definition of risk posed by site contaminants and assist with the definition of cleanup requirements.

- **Cleanup Standards.** Cleanup standards are defined in an FS for all media, such as soil and groundwater, that have been impacted by contamination and that could pose a risk to human health or the environment. Cleanup standards consist of the cleanup levels for hazardous substances present at the site and the location where these cleanup levels must be met (point of compliance).

- **Cleanup Action Alternatives.** Cleanup action alternatives are developed and presented in the FS. These alternatives consist of technologies that clean up site contaminants by reuse or recycling, destruction or detoxification, immobilization or solidification, disposal, containment with engineering controls or institutional controls and monitoring. These cleanup action alternatives must meet the following MTCA requirements (WAC 173-340-360): (1) protect human health and the environment, (2) comply with cleanup standards and applicable federal and state laws, (3) provide for compliance monitoring, use permanent solutions to the maximum extent practicable, (4) provide for a reasonable restoration time frame, and (5) consider public concerns.

- **Remediation Levels.** Remediation levels are proposed in an FS. As required, remediation levels always exceed cleanup levels and are concentrations of a hazardous substance above which a particular cleanup action component will be required as part of a cleanup action at a site. Remediation levels may be used at sites where a combination of cleanup action components are used to achieve cleanup levels at the point of compliance.

The FS is intended to provide enough information to allow Ecology to select a cleanup action. The procedures for conducting a feasibility study are set forth in WAC 173-340-350(8). The selection of a final cleanup action is documented in the Cleanup Action Plan.

2 Background

This section presents an overview of current conditions at the site, including the natural and built environment, historical information, and key environmental conditions. The objective is to present the information on the affected environment pursuant to the requirements of MTCA.

2.1 Town and Site Description and History

This section first describes the Town of Skykomish, Washington, and then locates the site within the town. It is important to not only understand the layout of the site, but also the town because the alternatives for cleanup of the Former Maintenance and Fueling Facility will impact areas of the town that are not on BNSF property. In addition to describing the town and site, the operational history of the Former Maintenance and Fueling Facility is also summarized. Sections 2.2 and 2.3 describe the natural and built environment of the town and the site.

2.1.1 Town Description

Historically, Skykomish was the commercial center of the Upper Skykomish Valley. The Town of Skykomish was incorporated in 1909, and mining, lumbering, milling, and the railroad were its economic mainstays. In 1929 the town had a population of 929, but it has since declined to its current level of 214 (U.S. Census Bureau, 2001). It is estimated that seasonal residents bring the total population to between 250-300 people (Blanck, 2003). Skykomish is located in King County, Washington at an altitude of 950 feet above mean sea level (msl).

In 1893, train service to Seattle started along the Great Northern Railway (GNR), and the Town of Skykomish became a center for railroad operations, including a roundhouse, turntable, and electrical generating substation. Active railyard operations in Skykomish had ceased by 1974. The BNSF railroad still runs through town, but railyard activities are limited to track maintenance and snow removal. The railroad continues to be a BNSF main transcontinental route with approximately 24 trains passing through Skykomish daily (Yates, pers. comm., 2003a).

Skykomish was built near the mouth of Maloney Creek where it connects to the South Fork of the Skykomish River. Maloney Creek was diverted from its original course in approximately 1912, and many channel modifications have occurred since then (USFS, 1991). The original course of Maloney Creek was located along the southern boundary of the railyard, and developed into a marshy area collecting stormwater drainage from the railyard and the southern part of town. This area is marked on Figure 2-1. The current course of Maloney Creek runs south of town.

To protect the town from flooding from the South Fork Skykomish River, the United States Army Corps of Engineers (USACE) constructed a flood control levee in 1951 along the riverfront east and west of the Skykomish Bridge, which was built in 1939. The levee is marked on Figure 2-1.

No logging or mining activities are ongoing in the Skykomish area. The town is surrounded on all sides by the Snoqualmie-Mount Baker National Forest (Figure 1-1). This portion of the National Forest is in Management Area 27-SF, part of which is Scenic Forest. Scenic Forest is managed to enhance viewing and recreational experiences (USFS, 1990 and USFS/USDI BLM, 1994). Scenic forest is a designation made by the Forest Service to describe land managed to enhance viewing and recreational experience. These areas include parcels with various designations that influence the Forest Service's management of each parcel. Area 27-SF includes stands such as Late Successional Reserve, which are managed for the growth and protection of old growth forest, recommended Wild and Scenic River, and many other designations all managed in different ways to enhance viewing and recreational experiences.

Today the town is dependent on tourism and on the Forest Service maintenance yard and ranger station. The other major employer is the Skykomish School District.

2.1.2 Site Description

The BNSF Former Maintenance and Fueling Facility in Skykomish, Washington, operated from the inauguration of the GNR line to Seattle in 1893 until 1974. The railroad line still runs through the facility, the property of which is owned by BNSF. The historical activities at the facility resulted in a release of hazardous substances that has impacted the railyard, adjacent properties, and natural features in the area such as the former Maloney Creek channel. The affected areas subject to potential cleanup action, whether BNSF property or otherwise, are collectively referred to as "the site" in this Final FS. BNSF's property is referred to as "the facility" and "the railyard." Figure 2-1 shows the general layout and boundaries of the site and the facility. The site covers approximately 40 acres, and the facility covers approximately 22 acres.

For purposes of this Final FS, the site is defined by contamination detected in soil, sediment, or groundwater samples exceeding the levels below. Boundaries were drawn to avoid cutting through properties as much as possible. The precise boundaries may be adjusted based on additional sampling that will occur during remedial design and compliance monitoring, after a final cleanup action is selected. The outline contains all areas with:

- Greater than 0.2 milligrams per liter (mg/L) of total petroleum hydrocarbons (TPH) (by NWTPH-Dx Method) in groundwater

- Any presence of free product
- Soil exceeding 20 milligrams per kilogram (mg/kg) for arsenic and 250 mg/kg for lead
- Soil TPH-Dx exceeding 20 mg/kg.

The site has been subdivided into several distinct Cleanup Zones (based on RI and Supplemental RI sampling) for this FS (see Section 6 for further discussion of Cleanup Zones):

1) **The Railyard Zone.** This area includes the former maintenance facility, together with two small adjacent areas, and covers approximately 22 acres. It has historically been used for industrial purposes. Surface and subsurface impacts are present.

2) **The Developed Zones.** These areas are or are likely to be developed for residences, commercial buildings, public buildings, or roads. These areas are primarily affected by contaminants in groundwater and surrounding subsurface soil. Hydrocarbon plumes consisting of a mixture of diesel and bunker C affect the NW Developed Zone and the South Developed Zone (Figure 2-1). The NE Developed Zone is affected primarily by diesel. In addition, there are some isolated elevated occurrences of lead in the surface soil north of the railyard.

   Diesel oil is a complex combination of hydrocarbons, having carbon numbers predominantly in the range of C9 to C20. The formulation and composition of diesel varies according to its intended use. There are two main types of diesel; these are Type 1 (kerosene and marine fuel) and Type 2 (automotive and locomotive fuel). Diesel fuel generally contains low concentrations of PAH compounds.

   The composition of bunker C fuels is less consistent than that of diesel fuel. Bunker C represents a fuel mixture which generally contains both diesel-range (C12 to C25) and oil-range (C25 to C36) hydrocarbons. In this document, NWTPH-Dx analyses have typically quantified the C12 to C36 hydrocarbon ranges to include both diesel and oil-range hydrocarbons. Bunker C fuels generally contain higher concentrations of PAH compounds than diesel fuels. The viscosity of bunker C is higher than that of diesel and when the two types of hydrocarbon are present together they form an emulsion.

3) **The Aquatic Resource Zones.** There are two Aquatic Resource Cleanup Zones; these are (i) The South Fork Skykomish River and

Levee, and (ii) The former channel of Maloney Creek. The South Fork Skykomish River and Levee includes the flood control levee downgradient of the NW Developed Zone, and the interface between land and the South Fork Skykomish River. This area is affected by seepages of hydrocarbon reaching the river. The second Aquatic Resource Zone is the former Maloney Creek channel. This area occupies a wetland area centered around the former Maloney Creek channel, which now functions as a local drainage during high runoff periods due to snowmelt or precipitation, and a stormwater conduit. This area has impacted surface sediment and also contaminated subsurface (smear zone) soil contiguous with Railyard Zone subsurface soil.

2.1.3 Railyard Operational History

As mentioned above, the facility was originally owned and operated by the GNR, starting in the summer of 1893. GNR owned the property from the late 1890s until 1970 when GNR merged with four other railroads and became the Burlington Northern Railroad (BNRR). The facility is currently owned and operated by BNSF that was formed with the merger of BNRR and the Atchison, Topeka and Santa Fe Railway in 1994.

The facility has gone through five overlapping operational eras. Each era is discussed below in terms of the activities conducted and the products used during the era. Figure 2-2 shows the location at the facility of the major elements discussed below.

2.1.3.1 Coal and Steam Era

Steam produced by coal heat was used to power locomotives operating out of the facility during this era. Structures reportedly present during this time period included an engine house and turntable, sandhouse, blacksmith and machine shop, coal tower and chute, depot, and water tower. The engine house originally had nine stalls for repair work but, by 1902, only six stalls were being used. Each stall had a pit where a repairperson could service the underside of a locomotive.

Repair activities reportedly performed during this era included insulation of engine parts and boilers, cleaning and rebuilding seals, cleaning and repairing boilers, testing gauges, oil and degreasing, painting, and cleaning engine parts. The turntable was used to turn the locomotives around. The sand tower dispensed sand that the locomotives used for traction on steep grades. The machine and blacksmith shops were used to manufacture parts for repairs. Petroleum-related products reportedly used during this period included grease, lubricating oil, and fortnite oil (kerosene-like petroleum product used to clean parts).

2.1.3.2 Oil and Steam Era

Bunker C oil replaced coal as the heat source in steam locomotives in about 1908. An oil-unloading shed and sump and an aboveground oil storage tank replaced the coal tower and chute. Bunker C oil was stored at the facility in below-grade wooden, concrete, and steel sumps, and aboveground steel tanks. Fortnite oil was the only cleaning fluid reported to be used during this period. The depot was moved from the south side of the tracks to its present location north of the tracks on Railroad Avenue.

2.1.3.3 Electric Era

Construction of an 8-mile-long tunnel between Skykomish and Leavenworth and of an electric substation was completed in 1929. Electric-powered locomotives replaced bunker C oil-powered locomotives through the tunnel to eliminate exhaust fumes. The facility became the transition point for bunker C oil- to electric-powered locomotives.

The engine house was used for repairs on both road and helper engines, until it was destroyed by a fire in 1943. However, evidence suggests that some elements of engine repair and maintenance continued at the facility through the mid-1950s.

2.1.3.4 Diesel Era

Diesel was used for locomotives traveling west of Skykomish as early as the mid-1940s and replaced both bunker C oil and electricity. In 1956, installation of a tunnel ventilation system permitted diesel locomotives to operate within the tunnel and electric locomotives were abandoned. The diesel was stored at the facility in aboveground and underground storage tanks until 1974 when BNRR discontinued fuel-handling activities at Skykomish.

2.1.3.5 Maintenance Era

Most engine repair and maintenance activities ceased in the mid-1950s. The electric substation building was used as a sandblasting facility for a period in the 1960s. The sandblasting facility is the probable source of the elevated concentrations of lead in the immediate vicinity of the former substation. BNRR discontinued all fueling operations at their Skykomish facility in 1974. At the same time, they also reportedly excavated and removed all known sources of petroleum product.

The demolished buildings and structures of the facility are shown on Figure 2-2. The substation was demolished in August 1992. The depot building and maintenance building are the only structures remaining at the facility. Three sets of railroad tracks and at least four spur lines surrounded by railroad ballast and gravel make up the remainder of the facility, which is currently used as a base of operations for track maintenance and snow removal crews.

2.2 Natural Environment

This section describes the natural environment of the Town of Skykomish and the site. The intention of this section is to describe the geology (soil and sediments) that exists under and around the town and site in order to understand the potential migration of contaminants.

Contaminants can potentially migrate through, and over, the ground via groundwater flow, surface water flow, stormwater runoff and infiltration, and floods. As such, to determine the movement of surface water and groundwater, one must first understand the surface topography and geology (Section 2.2.1). Then one can understand how the soil materials either facilitate or limit the movement of water both horizontally and vertically. The next aspects of the natural environment that will be described in this section are water (Section 2.2.2) and air (including wind) (Section 2.2.3).

Finally, this section will describe the plants, animals, and aquatic life that exist on and around the town and site (Sections 2.2.4 to 2.2.6). The human (or built) environment of the town and site is described in Section 2.3. This includes features such as historic and cultural resources, buildings, roads, bridges and railyard facilities. Adverse impacts to the built and natural environment, and mitigation measures, are described in Section 7 of the Draft FS/EIS and will be further described in the DSEIS and the Final EIS.

2.2.1 Earth

This section describes the geology, soils, sediment, topography, and unique physical features of the town and the site.

2.2.1.1 Geology and Soils

The Former Maintenance and Fueling Facility is located in the Skykomish Valley on the southern bank of the South Fork Skykomish River in Washington State. The Skykomish Valley is a classic, glacially scoured valley with steep sidewalls and a relatively flat bottom. The South Fork Skykomish River, flowing from east to west adjacent to the site, now occupies the northern side of the valley at the railyard. Over time, the river has meandered from the north side of the valley to the south side of the valley, as evident in the riverine deposits that dominate the geology on the valley floor. These deposits include sand, gravel, cobbles and boulders.

The South Fork Skykomish River receives its water from small tributaries upstream and spring snowmelt. Further downstream from the site, the Skykomish and Snoqualmie Rivers merge and form the Snohomish River, which flows into Puget Sound at Everett, Washington.

The Town of Skykomish is primarily underlain by highly heterogeneous glaciofluvial sediments. These glaciofluvial sediments consist mainly of sand

and gravel, and underlie a generally thin layer of topsoil and/or fill. Figure 2-3 presents a typical cross section through the site that illustrates the variability of the soils underlying the site.

Silty sand and/or fill generally up to 2 feet thick is present throughout residential and commercial areas within the site. The silty sand is loose to medium dense, and is gravelly in places and contains trace amounts to abundant organic material ranging from leaf matter and twigs to logs. The fill is a sandy silt containing brick fragments, broken glass, nails, and is in some areas underlain by a distinct orange burn horizon.

Native soils generally underlie the topsoil although in places the topsoil is underlain by fill that was used to level the land surface or fill in marshy areas. The fill contains brick fragments, broken glass, nails, and is in some areas underlain by a distinct orange burn horizon that was produced when the land was being deforested for development. This burn horizon is present up to 5 feet below the ground surface, indicating that the top 5 feet of the ground in some areas consists of fill. The native soils consist primarily of sand and gravel, with shallow discontinuous lenses of silt and clay. The ratio of sand to gravel varies greatly with depth and laterally throughout the site, and the grain size of the sand and gravel is also highly variable. The sand is generally medium- to coarse-grained and the gravel is fine to coarse. There are frequent cobbles up to one foot in diameter and occasional boulders up to 3 feet across.

The cross section in this FS (Figure 2-3) and the cross-sections presented in the Supplemental RI (RETEC, 2002) differ slightly from the cross-sections provided in the RI (RETEC, 1996) and reflect new information developed about the site since 1996. The geologic interpretations have been based primarily on the geologic logs collected for the Supplemental RI, because the boreholes were advanced using RotoSonic drilling for the Supplemental RI compared to Air Rotary for the RI. The RotoSonic drilling method provided more complete, continuous soil samples than the samples provided for the RI, and therefore the logs and cross-sections prepared during the Supplemental RI and this FS are more complete than those prepared for the original RI. A layer of dense silt is generally present within the sand and gravel throughout the entire site. This is at least 4 feet thick and in places is greater than 10 feet in thickness. The top of the silt shows subsurface relief that probably results from irregular erosion by the South Fork Skykomish River; however, in general, the upper surface of the silt gently rises from an approximate elevation of 905 feet at the western part of the site to 925 feet at the eastern end. The silt is present at depths between 10 and 27 feet below the ground surface.

Previous site investigations have not reached bedrock; however, the base of the soils is estimated at an approximate depth of 200 to 250 feet according to local area well logs (GeoEngineers, 1993). Additional information on soil is provided in Section 3.2.1, which summarizes soil quality data collected as part of the site RI and Supplemental RI (RETEC, 1996 and RETEC, 2002a).

2.2.1.2 Sediment

The site includes two separate areas where sediment may be subject to cleanup activities. These are the former Maloney Creek channel and the south bank of the South Fork Skykomish River west of the 5th Street Bridge. These two areas have substantially different characteristics. The former Maloney Creek channel is discussed in more detail in the next section (Former Maloney Creek Channel/Wetlands). The South Fork Skykomish River is discussed below.

The South Fork of the Skykomish River is a high-energy river (gradient is approximately 27 feet per mile) carrying a relatively low load of suspended sediment. In general, depositional environments are few and ephemeral in the South Fork, and the riverbed is dominated by heavier glaciofluvial materials (sands, gravels, and cobbles), which are less subject to scour than the finer sand and silt typically considered "sediment." Sand occupies many of the interstices of the larger substrate materials in the channel.

In Skykomish, the river makes a significant bend at the Fifth Street Bridge (Fig. 2-2). Along the River's southern shoreline, adjacent to the levee and the locations of hydrocarbon seeps (Figure 2-4), finer sediment may be deposited as a result of lower river velocities, particularly during low seasonal flows. The sediment deposited in this area is typically eroded on at least a seasonal basis during higher flows and, as a result, these deposits are considered ephemeral in nature. In addition, large riprap and cobble substrates associated with the levee form a near-vertical shoreline edge along the south riverbank, approximately 1 to 2 feet in height, relative to the riverbed elevation, also indicating a non-deposited environment where hydrocarbon seeps have historically been observed.

The larger riprap and boulders emplaced during levee construction along this shoreline may reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. At times, sediment accumulates in these areas. However, the sediment seldom appears to exceed a few inches in depth, except in the interstices between cobbles. This sediment grades into bank soils accumulated between cobbles in the riparian zone. The total width of this area is approximately 10 feet and represents the extent of the sediment resource in the South Fork Skykomish River.

A sediment impact zone was identified as part of the Supplemental RI (Figure 2-4). The Supplemental RI and subsequent sediment work detailed in the *Results of Supplemental Sediment Sampling – Toxicity Evaluation and Sediment Cleanup Levels* (RETEC, 2003a) identified an area of sediment concern covering approximately 440 feet along the bank, for a total area of approximately 8,117 square feet (see Appendix A). The actual extent of sediment accumulation areas affected by bank seepage is generally limited to transient accumulations in a strip less than 10 feet (generally 1 to 3 feet) wide inside the study area, for a total of 440 to 1,320 square feet.

The sediment accumulation is dominated by sand with lesser amounts of silt. The organic carbon content in the sediment appears to vary seasonally. Samples collected higher on the bank for the Supplemental RI during summer of 2001 had an average total organic carbon (TOC) of 1.1 percent. Samples collected lower on the bank during fall of 2002 had an average TOC content generally lower than 0.3 percent. The higher TOC samples are submerged only during high flows.

Further information on sediment quality in the South Fork Skykomish River is presented in Section 3.

2.2.1.3 Former Maloney Creek Channel

The former Maloney Creek channel is present along the southern boundary of the railyard to the east of 5th Street. A Wetland Detailed Study of the former channel appears in Appendix B. This former Creek channel has been impacted by former site conditions, and may be potentially affected by the cleanup actions. The eastern boundary of this area is from the culvert under Old Cascade Highway where the drainage ditch crosses to the north side of the road adjacent to the site. Stormwater drains into ditches adjacent to the road and flows through the culvert under Old Cascade Highway to the north side of the road adjacent to the site. Flow is intermittent through these ditches, and the ditches are dry for much of the year. At the western boundary, the former Maloney Creek channel passes through a culvert under the intersection of 5th Street and Old Cascade Highway to a point downstream of the Fire Station, where the flow emerges before reaching the current channel of Maloney Creek (Figure 2-5).

The preliminary delineation that was previously used is larger than that shown in Figure 2-5. As such, the estimates of volume and cost in the Former Maloney Creek Aquatic Zone are conservative.

Maloney Creek occupied the former Maloney Creek channel prior to being rerouted to its current location in approximately 1912 (USFS, 1991). Wetlands or other low-lying areas may have existed in the riparian corridor along the borders of the former creek prior to being rerouted, but the former channel and associated wetlands are now classified as a depressional outflow wetland. The former Maloney Creek channel now receives runoff from roads and residential yards via a culvert from the ditches on the south side of the Old Cascade Highway (Figure 2-5). The Wetland Detailed Study contained in Appendix B provides additional description of the wetland.

In the area between the culverts the channel widens and forms a wetland covering approximately 0.95 acres. The area is wooded, with a healthy population of alder, cottonwoods, and other native and non-native water tolerant shrubs. The BNSF facility bounds the area to the north, and residential properties and Old Cascade Highway bounds it to the south. The complete Wetland Detailed Study contained in Appendix B provides the delineation, characterization, and functional analysis of this wetland. Water content is intermittent, fed primarily by runoff from the drainage ditches and the railyard, but probably also by groundwater recharge during times of high water tables. During times of water flow salmonid fish have been observed in the wetland as well as in the drainage ditches upstream of the wetland (Ecology 2002b).

Figure 2-5 shows the former Maloney Creek channel, with a longitudinal cross section illustrating its hydrogeologic relationship with the surrounding soil. The channel substrate consists of silt and sandy silt of varying depth, but generally extending a few feet, overlying the typical glaciofluvial deposits of the area. Groundwater levels generally are deeper than the bed of the channel by 1 foot or more.

Contaminated soils are present in the subsurface along portions of the channel, and may reach the surface locally near location 02SED-5. The biologically active top foot of the wetland is dominated by historical and current surface runoff via the stormwater collection systems described in Section 2.2.3, and probably some localized intermittent upwelling in the neighborhood of 02SED-5.

The sediment quality in the former Maloney Creek channel sediment will be discussed further in Section 3.4.2. Contamination present in the glaciofluvial deposits in the deeper subsurface is contiguous and congruent with the subsurface contamination in the railyard soil, and will be addressed separately from the surface wetland. The quality of the deeper zone is also discussed in Section 3.2.1.

2.2.1.4 Topography

The topography of the town and the surrounding area south of the river is shown on Figure 2-6. The east end of the town is generally the highest part of town, nearing 950 feet above sea level. The west end of town descends to 920 feet above sea level. The lowest portions of the town include the former Maloney Creek channel, Maloney Creek, and the South Fork Skykomish River. The land south of the former channel of Maloney Creek is relatively flat-lying within 500 feet of the Site. This area is also relatively low-lying (approximately 920 ft-msl). As seen on Figure 2-6, the railroad tracks are built up higher than the rest of the town. North of the railroad tracks, the topography is relatively flat, but gently slopes down from east to west towards the South Fork Skykomish River.

2.2.1.5 Unique Physical Features

Human activity has strongly modified three distinct areas in the town. These include residential and business areas, flood berms, and the railyard. The residential and business areas contain single-family homes, and commercial and public buildings. Areas that are not covered by buildings or roadways generally consist of grass lawns.

Fifteen-foot high levees (berms) have been installed near the South Fork Skykomish River for flood protection. These berms are composed of fill material made up of sand and gravel. Boulders armor the surface of the north side of the berms, but the percentage of boulders within the berm is unknown. The locations of the berms are shown on Figure 2-1.

The third distinct area is the railyard. Gravel up to 1 inch in diameter surfaces the railyard on the majority of BNSF property (Figure 2-1).

The former Maloney Creek channel, along the southern boundary of the railroad yard, conveys stormwater draining from the railyard and street as well as runoff from residential yards south of the Old Cascade Highway. It includes a wetland that is described in detail in subsequent sections and Appendix B (see Figure 2-1). This area has a layer of silt or silty sand overlaying glaciofluvial area sediments.

2.2.2 Water

This section describes the occurrence and flow of groundwater and surface water throughout the Site. This section also introduces references to water quality; greater detail is provided in the analysis of nature and extent of contamination in Section 3. The water described in this section includes surface water, runoff and infiltration, floods, groundwater, and water supply wells.

2.2.2.1 Surface Water Movement, Quantity, and Quality

Surface waters in and nearby the town include the South Fork Skykomish River, the wetland in the former Maloney Creek channel, and Maloney Creek (Figure 2-1). These three surface water features are described below.

Additional information is provided in Section 3.5, which summarizes surface water quality data collected as part of the remedial investigations at the site.

South Fork Skykomish River

The South Fork Skykomish River is a fast flowing river with fluctuating flow and water levels throughout the year. It receives its water from small, upstream tributaries and spring snowmelt. The South Fork Skykomish River contains flowing water all year.

Water levels are lowest in the late summer (July, August, September, October). Table 2-1 summarizes mean river flow in cubic feet per second (cfs) and river height. River flow is gauged at the Gold Bar gauging station, located approximately 20 miles downstream of the town. River height is gauged at a USACE electronic water level gauge on the 5th Street Bridge over the South Fork Skykomish River. Gold Bar data can be accessed in real time while 5th Street Bridge data is available on a time-delay basis. There is a correlation between the Gold Bar flow data and river depth at the 5th Street Bridge. Therefore, Gold Bar flow data can used to calculate water depths at the Skykomish Bridge in real-time (RETEC, 2002b). Tributaries flowing into the river between Skykomish and Gold Bar cause the flow at Gold Bar to be greater than the flow at Skykomish. A heavy storm event can cause the water level to rise several feet overnight as the water flow increases.

Low-velocity areas are present in the river margin along the base of the levee throughout much of the southern shoreline. Particularly downstream of the bridge, large riprap and cobble substrates form a vertical shoreline edge along the south riverbank which is approximately 1 to 2 feet in height, relative to the riverbed elevation. The larger riprap and boulders present along this shoreline reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. Low-flow areas are also present within the interstices of the larger boulders and riprap. The base of this shoreline edge is at approximately 4.5 to 5 feet gauge height. During flows above this height, water adjacent to the shoreline edge is approximately 1 to 2 feet deep. Below this height, the river recedes from the base in most areas.

Substrates within the South Fork Skykomish River are dominated by cobbles, and vary in size from large boulders and large cobbles, to smaller gravels and sands. Larger boulder substrates are more frequent along the northern portions of the channel, with smaller cobbles, gravels, and sands occurring along the southern shore. Larger cobbles, boulders, and riprap associated with the base of the flood control levee in the NW Developed Zone are also present along the southern shoreline. Gravels and sands occupy many of the interstices of larger substrates within the river channel.

The Former Maloney Creek Channel

Maloney Creek is thought to have originally flowed in a northerly direction across what is now the railyard and directly into the South Fork Skykomish River, without a significant change in flow direction. In about 1912, Maloney Creek was diverted to a new channel (USFS, 1991). A Sanborn Map, dated 1926 (Appendix C), shows Maloney Creek flowing along the same approximate course as the currently defined Former Maloney Creek Channel. In addition there is an area defined as a “shallow gulch” underlying the present site of the Skykomish library on the west side of 5th Street. The Sanborn Map suggests that the gulch was not connected with the creek channel and that the gulch was a closed basin. Subsequent infill has eliminated part of the southern portion of the channel and the Maloney creek channel has since been re-diverted to its current course; but the greater part of the Former Maloney Creek channel remains a wetland with intermittent water flow primarily from stormwater runoff from surrounding areas. This is the former Maloney Creek wetland (Figure 2-5).

The topography of the land adjacent to the former Maloney Creek channel indicates that historically, discharges and runoff from the southern portion of the railyard as well as from the residential areas to the south probably flowed through the former Maloney Creek channel. Although no hydrologic studies are available for confirmation, it is likely that most of the intermittent flow during low water table conditions in the channel, and a significant portion of the water flowing through the channel during high water table conditions, is derived from surface runoff and drainage (see Appendix B). Sediment cores and samples were collected and analyzed as part of the Supplemental RI (RETEC, 2002a).

The former Maloney Creek channel can be described as three distinct segments, as described below:

- **The Upstream Segment.** This segment is south of the Old Cascade Highway. It is approximately 4 to 5 feet wide and is confined within a series of drainage ditches. Culverts convey flow beneath numerous roads and driveways along the south side of the highway. The substrate in this area is dominated by gravels and sands, with occasional small cobbles present.

- **Middle Section.** This segment is south of the railyard and north of the Old Cascade Highway and includes the wetlands described in Appendix B. Second-growth deciduous trees dominate this segment. The wetland, with its associated channel, is approximately 60 to 80 feet wide. The channel within the wetland is undefined throughout most of its length, with surface layers dominated by sands and silts overlain with varying amounts of organic debris. Small patches of gravel are also present in places. At lower flows, ponding occurs throughout this area.

- **The Downstream Segment.** This segment is downstream of the Old Cascade Highway culvert south of the firehouse. This segment is dominated by small cobbles and gravels, with areas of sand deposition. The channel is approximately 3 to 5 feet wide. The entrance to the culvert beneath the firehouse is approximately 400 feet upstream of the confluence, and the culvert itself is approximately 220 feet long.

The plant and animal species that live in these three areas will be discussed in Sections 2.2.4 and 2.2.5. The geology of this area is discussed in Section 2.2.2.4.

Maloney Creek (Current Channel)

Maloney Creek receives runoff from its drainage (catchment area), which includes the former Maloney Creek channel. Its catchment area is estimated to be approximately 1,914 acres and is shown on Figure 2-7. Maloney Creek drains into the South Fork of the Skykomish River to the west of the city. Maloney Creek contains flowing water all year; however, no gauging data is available. It demonstrates a pattern similar to that of the South Fork Skykomish River. Maloney Creek is also considered shoreline under the Shoreline Management Act of 1971 (Chapter 90.58 RCW).

2.2.2.2 Stormwater Runoff and Infiltration

There are three catchments that capture and pipe stormwater in the Town of Skykomish: the town catchment, the former Maloney Creek catchment, and the railyard catchment. The town catchment captures stormwater runoff north of the railroad tracks; the former Maloney Creek catchment, south of the railroad tracks; and the railyard catchment, from the south side of the railroad tracks. These three catchments are described below and illustrated on Figure 2-8.

Surface water infiltrates in unpaved areas on the north side of the railroad tracks.

Town Catchment

North of the railroad tracks, stormwater accumulates in one of four collection basins that flows by way of one of three culverts through the berms to the west of the South Fork Skykomish River Bridge and directly into the South Fork Skykomish River. The locations of these features are shown on Figure 2-8. In unpaved areas on the north side of the railroad tracks, stormwater does not accumulate in these collection basins but infiltrates through surface soil.

There is no municipal storm water treatment system in Skykomish.

Former Maloney Creek Catchment

The catchment area for the former Maloney Creek channel is approximately 42 acres, as shown on Figure 2-7. It is bounded by 5th Street to the west, the railroad tracks to the north, and extends no further than the residential areas to the east and south.

Stormwater runoff passes along ditches and through culverts in the former Maloney Creek catchment area. Figure 2-8 illustrates the locations of the culverts. Twenty-four-inch culverts generally pass in the east/west direction under streets and driveways along the Old Cascade Highway. The easternmost culvert passes under 4th Street and passes under each street and driveway to the west until it passes under the Old Cascade Highway in the northwest direction, connecting the flow to the former Maloney Creek channel. Water then flows through the channel to the west, receiving runoff from the railyard (discussed below).

Flow from the former Maloney Creek channel then passes through a 36-inch culvert under the fire station to the southwest. After the culvert, the stream runs approximately 400 feet until it joins the current Maloney Creek channel, leading to the South Fork of the Skykomish River.

Railyard Catchment

The former Maloney Creek channel receives runoff from the railyard. Stormwater on the southern side of the railyard flows to the west along the tracks to a depression just east of 5th Street. This depression or catch basin (cb) may be seen on Figure 2-8. At this depression, one culvert passes from this depression to the south where it discharges into the former Maloney Creek channel. Another culvert historically transferred stormwater from this depression to the north under the tracks, but has since been blocked by a telephone pole, which stops flow through this culvert.

2.2.2.3 Floods

The 100-year and 500-year flood map is provided as Figure 2-9. This map was prepared using 2003 FEMA data. A flood protection levee is located along the southern side of the South Fork Skykomish River to the west of the Skykomish River Bridge (Figure 2-1).

The 100-year flood is anticipated to flood all of the areas to the west of 5th Street and north of the railroad tracks, with the exception of the railroad tracks; the railroad tracks are elevated above the rest of the town, preventing much flooding in a 100-year flood on and to the south of the railroad tracks. The area north of East River Road and portions of the block between Railroad Avenue and East River Road will likely also be inundated in a 100-year flood. However, flooding would follow the Maloney Creek drainage corridor and flood the areas south of the creek.

A 500-year flood would cover the entire town north of the railroad tracks, but the entire portion south of Old Cascade Highway would be safe from flooding.

2.2.2.4 Groundwater Movement, Quantity, and Quality

To understand and predict the movement of groundwater, one must understand the types of soil that exist at a site because groundwater exists in the ground in spaces between soil particles. Water moves easiest through soil with larger grain sizes because these soils cause larger spaces between them. Water has a more-difficult time moving through soils with smaller grain sizes.

Soils with larger grain sizes at the site are gravel and sand; whereas, soils with smaller grain sizes include clayey silt. As such, the movement of groundwater based on the geology of the site will be analyzed in this section.

Regionally, the site is located within the Skykomish Valley, a relatively steep-sided, rock-walled valley that has been partially filled with glaciofluvial sediments. These glaciofluvial sediments consist mainly of sand and gravel. The direction of regional groundwater flow along the Skykomish Valley is westerly, in a downslope direction coincident with the slope of the floor of the valley.

Shallow groundwater is present in the sand and gravel aquifer underlying the site. The aquifer materials vary greatly in the size and proportion of the sand and gravel; however, in general, little silt or clay is dispersed throughout. The concentration of total organic carbon in the sand and gravel generally ranges between approximately 0.1 and 0.5 percent. Where limited silts and clays are present within the upper sand and gravel, they typically occur as thin discontinuous lenses that will not affect the overall horizontal groundwater flow rate or direction throughout the aquifer; however, they may retard vertical groundwater flow, as described below. The lower silt that underlies the shallow sand and gravel is thicker than the abovementioned silts and clays and will retard vertical groundwater flow.

Depth to Groundwater

The depth to groundwater ranges approximately from 3 to 17 feet below ground surface throughout most of the site. In low-lying areas immediately adjacent to the South Fork Skykomish River, drainage ditches, and the former channel of Maloney Creek the groundwater may intersect the ground surface and therefore the depth to groundwater in those limited areas may be zero feet below the ground surface. The groundwater is generally shallowest close to the South Fork Skykomish River and increases in depth to the south. The shallow groundwater is hydraulically connected with surface water in the South Fork Skykomish River and former Maloney Creek channel. The South Fork Skykomish River bank is composed of sand and gravel, and is similar to the sand and gravel underlying the site, except that the bank is armored in places with coarse riprap. Groundwater flow through the bank is unlikely to be reduced or enhanced by the riprap.

The groundwater levels throughout the site are influenced by the river level, precipitation, temperature, and local drainage. These factors cause the groundwater levels to vary seasonally. Figure 2-10 shows hydrographs with monthly groundwater levels during 2002 and 2003 in 1A-W-3 and 2A-W-1. These hydrographs show that the measured groundwater levels have varied by 4 to 7 feet since January 2002. They were high during winter and spring and low during summer and fall. Precipitation patterns affect the exact duration and periods of the high and low water levels, as well as the magnitude of the groundwater level changes.

Groundwater elevations are the highest at the southeast corner of the Former Maintenance and Fueling Facility and decrease to the northwest towards the South Fork Skykomish River. Groundwater elevations are generally higher during late fall, winter, and spring (November to April) and lower in the summer and early fall (June to early November) (RETEC, 2001).

A 600-foot long subsurface barrier wall was installed in 2001 to intercept the migration of free product towards the river. This barrier wall was designed so that the groundwater levels would not increase by more than 5 inches behind the wall. Monthly fluid levels have been collected from selected wells behind the wall; these levels indicate that groundwater does not appear to be mounding behind the wall, and that groundwater passes under the wall without hindrance.

The former Maloney Creek channel is an intermittent wetland fed primarily by runoff but also occasionally by groundwater influx. The water table is located well below the bed of the channel during seasonal low groundwater levels. During measured seasonal high water levels the groundwater rises to a foot or less below the channel, and it is likely that at times groundwater surfaces in the former creek bed and feeds the channel. The former Maloney Creek channel is discussed further in the surface water section (above) and in Section 2.2.4.

Hydraulic Conductivity

Hydraulic conductivity values, a measure of permeability of the sand and gravel, have been calculated using laboratory and field tests; these tests have provided hydraulic conductivities between 41 and 84 feet per day for the shallow sand and gravel (RETEC, 1996). These values are representative of sand and gravels (Todd, 1980).

A clayey silt bed, which is 4 to more than 10 feet thick, underlies the entire site. The top of this silt is present at depths between 10 and 27 feet below the ground surface. The hydraulic conductivity of this unit has not been tested. However, the hydraulic conductivity of a similar clayey silt was measured to be 0.4 feet per day in the RI (RETEC, 1996); this is a representative value for silt (Todd, 1980). Because of the significantly lower hydraulic conductivity, this silt bed impedes vertical groundwater flow within the sand and gravel aquifer and acts as an aquitard.

Groundwater Flow Direction and Gradient

The groundwater flow in the shallow, unconfined sand and gravel aquifer varies throughout the site; however, most groundwater flow throughout the site is horizontal. There is no evidence that preferential channels are present within the site that may affect groundwater flow direction, although silt and clay lenses within the gravelly sand unit can potentially change groundwater flow direction due to the difference in hydraulic conductivity between the silt and the sand and gravel. Groundwater usually has some vertical component to flow; however, the vertical flow is restricted by the silt aquitard.

Groundwater levels measured during several gauging events indicate that the overall flow directions within the site are relatively consistent with time. Figure 2-11 presents a groundwater surface elevation map that was prepared using groundwater levels collected during January and February 2002. East of 4th Street, the groundwater generally flows from south to north, towards the South Fork Skykomish River with an average gradient of 0.14 feet per foot (that is 0.14 vertical feet per one horizontal foot). To the west of 4th Street, the groundwater flows from the southeast to the northwest with an average gradient of 0.01 feet per foot (RETEC, 2002a). The hydraulic gradient indicates that groundwater flows at an average rate of 2.5 feet per day (ft/day) (RETEC, 2002a). Groundwater contour maps and additional details on groundwater flow are contained in the Supplemental RI (RETEC, 2002a).

Vertical gradients within the site have been measured using several pairs of wells co-located, but screened at different depths (RETEC, 1996). The measurements show that the gradients are low and do not indicate a strong vertical flow component. The downward vertical gradients are greatest during periods of high groundwater (heavy rainfall) and the lowest gradients have occurred during periods of low rainfall, when groundwater levels are low. This downward gradient is due to rainfall infiltration recharging the groundwater and the effect of the aquitard impeding flow from the overlying sand and gravel to the underlying sand and gravel.

Groundwater Quality

Additional information is provided in Section 3.2.3, which summarizes groundwater quality data collected as part of the Supplemental RI (RETEC, 2002a).

2.2.2.5 Water Supply

No water supply wells are located in the Town of Skykomish. The people of Skykomish are served by two public water supply wells that are located about 1,100 feet east (upgradient) of Skykomish. The primary well is completed to a depth of 216 feet below ground surface (bgs) and is screened across three intervals between 181 and 216 feet bgs. A backup well is located adjacent to the primary well and is completed to a depth of 219 feet bgs. In 1993, the water system pumped an average of 70,000 gallons per day and 2,100,000 gallons per month. Storage capacity was provided by one water tank with a capacity of 220,000 gallons. Water from the public water system has been sampled and no contaminants related to the site have been detected.

2.2.3 Air

2.2.3.1 Climate

The climate of the project region is predominately maritime with cool and relatively dry summers and mild, wet, and cloudy winters. Total annual precipitation is approximately 110 inches per year with an annual average snowfall of 55 inches. Mean average temperature in Skykomish is 49.3 °F. Daily mean high and low temperatures for January are 49.3 °F and 35.8 °F, respectively. Daily mean high and low temperatures for August are 79.6 °F and 68.7 °F, respectively (National Climatic Data Center, Washington State Narrative Summary, 2003).

The influence of semi-permanent high- and low-pressure areas over the North Pacific Ocean dominates winds in the area. Air circulates in a clockwise direction around the semi-permanent high-pressure cell and in a counter-clockwise direction around the semi-permanent low-pressure cell. During the summer, the low-pressure cell becomes weak and moves north of the Aleutian Islands and the high-pressure cell brings a prevailing westerly and northwesterly flow of comparatively dry, cool, and stable air into the Pacific Northwest. Winds in the area are predominately southwesterly to westerly during most of the year. Northeasterly to easterly winds dominate from November to February. Annual average wind speeds are 5.6 knots with peaks of up to 32 knots in the winter months.

2.2.3.2 Air Quality

Air quality is generally assessed in terms of whether concentrations of air pollutants are higher or lower than ambient air quality standards set at levels protective of human health. Based on an ambient monitoring data collected from a network of monitoring stations throughout the region, areas are designated as being in “attainment” or “nonattainment” for particular pollutants.

Skykomish is currently in attainment of ambient air quality standards for all criteria pollutants. This status indicates that the region meets the National Ambient Air Quality Standards (NAAQS) for all pollutants. However, the site is located on the boundary of an area that was designated as nonattainment for ozone until 1996. This area, which incorporates all but the extreme northwest portion of King County, is currently subject to a maintenance plan for ozone approved by the United States Environmental Protection Agency (EPA). The maintenance plan for ozone addresses fuel specifications for mobile sources, inspection and maintenance programs for automobiles, and industry-specific rules. The only significant sources of ozone precursors in the Skykomish area are automobile and train traffic. This project will not be directly affected by the current ozone maintenance plan.

The Puget Sound Clean Air Agency (PSCAA) is currently in the process of updating the maintenance plan for the region.

No stationary industrial sources of air pollution have been identified in the proximity of the site. Automobiles travel in the town and on the busier Northeast Stevens Pass Highway (U.S. 2) at the north end of town. Approximately 24 trains pass through Skykomish on a daily basis (Yates, 2003a) and are responsible for diesel exhaust emissions, but they do not routinely stop and idle in town.

Additional information is contained in Section 3.2.6, which summarizes air quality data collected as part of the RI, Supplemental RI and other investigations.

2.2.3.3 Odor

No industrial odor sources are present in Skykomish. Emissions resulting from diesel exhaust from daily trains passing through Skykomish may be a source of odors. Seepages of hydrocarbons have been noted at a number of locations along the South Fork Skykomish Riverbank. These seepages are the source of hydrocarbon odors along the levee, particularly during low flow conditions and calm winds.

2.2.4 Plants

This section describes the plant life in the Town of Skykomish and at the site. It includes information on the habitats of plants, special plant status, and noxious weeds. Additional information on terrestrial species is provided in the *Revised Terrestrial Ecological Evaluation* submitted to Ecology on March 26, 2004 (Revised TEE). The Revised TEE is Appendix D to this Final FS.

2.2.4.1 Plant Habitat Diversity

The site is located in the western hemlock (*Tsuga heterophylla*) vegetation zone, the most widespread vegetation zone in western Washington (Franklin and Dyrness, 1973). The mild climate of this zone supports growth of productive coniferous forests dominated by Douglas fir (*Pseudotsuga menziesii*), western hemlock, and western red cedar (*Thuja plicata*). Common understory plants include swordfern (*Polystichum munitum*), salal (*Gaultheria shallon*), red osier dogwood (*cornus sericea*), vine maple (*Acer circinlum*) and huckleberry (*Vaccinium spp.*).

The majority of the site is within the developed portions of the Town of Skykomish, consisting of BNSF railyards, and residential and commercial properties. Two small parcels of undeveloped, forested land are adjacent to the site, north of Maloney Creek and at the Maloney Creek outlet. Figure 2-12 shows the habitat types present in the site vicinity. The botanical resources of each of the mapped habitat areas at the site are described below.

Railyard

The railroad yard is an open habitat mostly covered in gravel and sparsely vegetated with grasses and weedy forbs. The area is subjected to high levels of soil and vegetation disturbance, including heavy railroad traffic. It provides low quality habitat for plants.

Residential and Commercial

Habitat in these areas includes buildings, paved roads and sidewalks, paved and graveled driveways, turf grass lawns, home gardens, and a variety of trees and shrubs. Small shrub thickets and young to mature second-growth trees are scattered throughout the area. Weedy non-native species are present along disturbed roadsides.

South Fork Skykomish River Flood Control Levee and Shoreline

The south bank of the South Fork of the Skykomish River, which borders the Town of Skykomish, is developed and disturbed to the water's edge along most of its length. Young- and mid-successional-aged deciduous trees and scattered patches of shrubs are present along portions of the shoreline. Riparian habitat is poorly developed along the shoreline.

The riprap flood control levee occupies less than 1 acre along the south side of the river (Figure 2-1). Adequate soil is present to support understory vegetation and low density of trees and shrubs along the top and sides of the levee. The northern side of the levee, extending to the ordinary high water line of the river, is dominated by young big-leaf maple (*Acer macrophyllum*) and red alder averaging about 5 inches diameter at breast height (dbh).

Swordfern, Himalayan blackberry (*Rubus discolor*), and giant knotweed (*Polygonum sachalinense*) are present in the understory. The top and southern side of the levee are dominated by grasses and shrubs with a few scattered small trees. Grand fir (*Abies grandis*), black hawthorn (*Crataegus douglasii*), tall Oregon grape (*Mahonia aquifolia*), and snowberry (*Symphoricarpos albus*) are present. Orchardgrass (*Dactylis glomerata*), English plantain (*Plantago lanceolata*), common tansy (*Tanacetum vulgare*), and mullein (*Verbascum thapsis*) are among the common non-native species present at the levee.

Upstream and downstream of the levee, the bank of the South Fork Skykomish River is occupied by residences with associated lawns and outbuildings. A few scattered trees and shrubs are present along the riverbank.

Former Maloney Creek Channel

The former Maloney Creek channel is dominated by early to mid-seral deciduous trees and shrubs, with the exception of the culvert inlet site, which is dominated by herbaceous species (see Appendix B). Black cottonwood, red alder and big-leaf maple are the dominant tree species. Red-osier dogwood (*Cornus sericea*) and salmonberry are the dominant shrub species. Native herbaceous species present in the wetland include large-leaf avens (*Geum macrophyllum*), small-fruited bulrush (*Scirpus microcarpus*), piggy-back plant, and common horsetail (*Equisetum arvense*). Non-native species observed at the site include giant knotweed, Himalayan blackberry, and Scot's broom (*Cytisus scoparius*).

The boundaries of the wetland area of the former Maloney Creek Channel are generally discernable, as it is bounded by the railyard area to the north and the Old Cascade Highway and residential development to the south, which have distinct slope breaks. The formal delineation and functional assessment is contained in Appendix B.

The following describes the plant species in the three segments of the former Maloney Creek channel introduced in Section 2.2.2.

- **Upstream Segment**. At the upstream end, the former Maloney Creek channel is confined to a narrow ditch vegetated with grasses, swordfern, salmonberry, and weedy forbs (Figures 2-13 and 2-14). Overstory trees are scattered along the south side of the ditch and include red alder, big-leaf maple, and a few young western red cedar (Figure 2-15). This reach functions as a roadside stormwater drainage ditch.

- **Middle Segment**. The middle section of the historic channel passes through a wetland (see Section 2.2.2, Surface Water Movement, Quantity and Quality). The wetland habitat is dominated by second-growth deciduous trees including red alder, big-leaf maple, and black cottonwood. The understory is dense in places and consists primarily of salmonberry, willow, and weedy species such as giant knotweed and Himalayan blackberry.

- **Downstream Segment**. At the downstream end, the channel is well-defined for a distance of about 400 feet, between the Old Cascade Highway culvert and the confluence with Maloney Creek. Vegetation along the lower section of the historic creek channel is disturbed second growth forest of big-leaf maple and red alder. The sparse understory is composed of salmonberry, vine maple, and sword fern. Residential yards and storage areas impinge in this area.

2.2.4.2 Special Status Plant Species and Habitats

All of the habitats at the site have been disturbed by human activity, such as industrial, residential or commercial development and timber harvest. Native, forested habitat is limited to a small second growth area along the former

Maloney Creek channel. This area is disturbed, with a high number of non-native understory species. The site habitats provide low potential for rare plant species, based on the level of current and historical disturbance. No populations of rare, threatened or endangered plant species are known or expected to occur on the former channel of Maloney Creek and none have been observed or reported.

The following lists the results of research on the special status plant species and habitats for the site:

- A search of the Washington State Department of Natural Resources Natural Heritage Program Database was requested for the site and surrounding areas. No data records for rare plants or high quality ecosystems are present in the database (WDNR, 2002).

- The Washington Department of Fish and Wildlife (WDFW) Priority Species and Habitats database was queried for the presence of priority habitats in the vicinity of the site. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species. No priority habitats were noted in the database (WDFW, 2003a). Riparian areas along the South Fork of the Skykomish River and Maloney Creek would qualify as priority habitats under the state guidelines. Wetland habitats, such as the wetland within the former Maloney Creek Channel, would also be classified as a state priority habitat.

- The United States Fish and Wildlife Service (USFWS) noted that white-top aster (*Aster curtus*), a federal plant species of concern, has been reported from King County (USFWS, 2003). This species is restricted to grassland habitats in the Puget lowlands; suitable habitat for the species does not occur in the Skykomish area.

- The Town of Skykomish Critical Area Ordinance (CAO) lists the South Fork Skykomish River and Maloney Creek shorelines as Primary Fish and Wildlife Habitats. For purposes of this evaluation, the former Maloney Creek channel and associated wetland are ranked as secondary fish and wildlife habitats, based on the lack of documented presence of species listed by the federal government or state of Washington as endangered, threatened, or sensitive (see Section 2.2.6, Fish and Aquatic Resources).

2.2.4.3 Noxious Weeds

Weed control activities on private and state lands in the Skykomish area are managed through the King County Noxious Weed Control Board.

Management goals for noxious weeds vary based on weed class: eradication of Class A weeds is required by state law; Class B designated weeds must be prevented from producing seed; and Class B non-designates and Class C weeds may be designated for control at the option of the local weed control board. On National Forest System lands near Skykomish, the United States Forest Service (USFS) administers weed management programs.

No Washington State Class A weeds are known or suspected to occur in the site vicinity. Six species of Class B designate weeds are known to occur in and near the Town of Skykomish (King County 2003a and 2003b):

- Orange hawkweed (*Hieracium aurantiacum*)
- Diffuse knapweed (*Centaurea diffusa*)
- Spotted knapweed (*Centaurea biebersteinii*)
- Dalmatian toadflax (*Linaria dalmatica ssp. dalmatica*)
- Sulfur cinquefoil (*Potentilla recta*)
- Policeman's helmet (*Impatiens glandulifera*).

One species of Class C weed, yellow toadflax (*Linaria vulgaris*), has been recorded in the area.

Orange hawkweed is common along roadsides throughout the Town of Skykomish and in the railyard area. Policeman's helmet is found in moist areas in the southwest side of town between Helen and Thelma Streets. BNSF currently implements management activities for orange hawkweed, diffuse knapweed, spotted knapweed, dalmatian toadflax, yellow toadflax, and sulfur cinquefoil along the rail line in the vicinity of Skykomish.

The USFS weed management program targets three weed species in the Town of Skykomish (USFS, 1999). Japanese knotweed and giant knotweed are present along the South Fork Skykomish River corridor and Maloney Creek corridor, and are prescribed for control efforts on National Forest System lands. Scot's broom is present on National Forest System lands along a transmission line corridor that passes through Skykomish. These species are listed as noxious weeds of concern by King County; control of these species is recommended (King County, 2003a).

2.2.5 Wildlife

This section describes the animal life in the Town of Skykomish and at the site. It includes information on the habitats of animals, special status species, and threatened and endangered species.

2.2.5.1 Wildlife Habitat Diversity

Wildlife habitats at the site are affected by ground disturbance, high human activity levels, and urban conditions, and are suitable primarily for wildlife species that are tolerant of these conditions. The wildlife on each of the mapped habitat areas at the site is described below (as illustrated on Figure 2-12).

Railyard

The railyard area receives high levels of human, vehicle, and train activity, and provides low value to wildlife. The grass and weed-dominated site is used primarily by birds and small mammals. Generalist species of disturbed habitats, such as coyote and raccoon, may also use the railyard area on occasion.

Residential and Commercial

Residential back yards in the Town of Skykomish support wildlife habitat for birds and small mammals that use inhabited sites and are tolerant of human activity. Bird species that are expected to be present in the area include, but are not limited to, American robin, house sparrow, Stellar’s jay, white crowned sparrow, common raven, common crow, barn swallow, violet green swallow, cliff swallow, rough-winged swallow and starling.

South Fork Skykomish River Flood Control Levee and Shoreline

The riparian zone along the south bank of the South Fork Skykomish River is of low quality due to the extent of development close to the shoreline. Animals that may use the shoreline habitat include, but are not limited to, common crow, coyote, raccoon, and mink.

Former Maloney Creek Channel and Wetland

The patches of forested and wetland habitat along the former Maloney Creek channel are expected to be used by various birds and mammals, including, but not limited to, towhee, dark-eyed junco, common bushtit, common crow, coyote, and raccoon.

2.2.5.2 Special Status Wildlife

The WDFW, USFS, and USFWS were contacted to determine the presence of special status wildlife species in the vicinity of the Site (Township 26 North, Range 11 East, Sections 26, 27, 33, 34, and 35), the results of the data requests are summarized below:

- **Cascades Frog.** The Cascades frog is a federal species of concern and a state monitor species. In Washington, the Cascades frog occurs at mid-to high elevations in the Cascades and the Olympic mountains (Leonard *et al*., 1993). It is rarely found below elevations of 2,000 feet. The species is most commonly found in small pools in sub-alpine meadows and also inhabits sphagnum bogs, forested swamps, small lakes, ponds, and marshes near streams.

No suitable habitat for Cascades frog is expected to occur in or near the Town of Skykomish at an elevation of 950 feet. No occurrences of Cascades frog were documented in state or federal databases (USFWS, 2003; WDFW, 2003a).

- **Northern Red-Legged Frog.** The northern red-legged frog is a federal species of concern that occurs at low to moderately high elevations in western Washington. It typically uses small ponds, pools, and swamps within forest stands (Leonard et al,. 1993). During the breeding season, the species is most abundant in ponds and pools that are seasonally, rather than permanently, flooded. Red-legged frogs breed in winter, attaching the egg masses weakly to emergent vegetation or underwater branches. Newly metamorphosed frogs, as well as mature adults, are more terrestrial than aquatic, inhabiting shrub and forested areas near permanent water.

  Red-legged frogs were not detected during wetland surveys of the former Maloney Creek Channel in July 2003. This species may occur in the vicinity of the site.

- **Oregon Spotted Frog.** Oregon spotted frog is a candidate for federal listing and a Washington State endangered species. Historically, Oregon spotted frog was present in the Puget trough lowlands from southern British Columbia to northern California and east into the Cascade Mountains in southern Washington and Oregon (Leonard et al,. 1993). Habitat loss, through modification of riparian and wetland habitat, is thought to be a major factor in the population decline. Currently, three populations of Oregon spotted frog are known in Washington State: one in the south Puget Sound, and two in the Cascade Mountains of south-Central Washington (McAllister and Leonard, 1997). One population is known from British Columbia and another 20 populations are documented in Oregon.

  Suitable habitat for Oregon spotted frogs is shallow, emergent wetlands, typically in forested settings (Leonard et al,. 1993). Oregon spotted frogs rarely leave the aquatic environment and are usually found in standing, shallow water with abundant emergent or floating vegetation. No suitable habitat for Oregon spotted frog occurs at the project site or vicinity of the Town of Skykomish. No observations of Oregon spotted frog have been reported in the vicinity of Skykomish (USFWS, 2003; WDFW, 2003a).

- **Tailed Frog.** The tailed frog is a federal species of concern and a state monitor species that occurs in cold, rocky streams from

British Columbia to northern California (Leonard et al., 1993). Tailed frogs inhabit cold, rocky streams from low to high elevation, spending several years as tadpoles. Adults are nocturnal and infrequently seen, emerging at night to feed on insects near the stream and in the adjacent forest. Adults can be found in summer, and tadpoles year-round, by turning over rocks in the stream. Tailed frogs do not inhabit ponds or wetlands.

Suitable habitat for tailed frog is not present at the site. The higher gradient reaches of Maloney Creek to the south of the site may support tailed frog. The population status is unknown.

- **Harlequin Duck.** The harlequin duck is a federal species of concern that has been documented to breed upstream of Skykomish along the Beckler River and downstream near the Miller River confluence (WDFW, 2003a). No records of breeding harlequin ducks have been reported along the section of the South Fork Skykomish River that borders the Town of Skykomish, or along Maloney Creek. Suitable breeding habitat occurs along fast-flowing streams and rivers with a well-developed, forested riparian zone. The site does not provide this type of habitat. Harlequin ducks may forage and loaf along the section of the South Fork Skykomish River that borders the Town of Skykomish.

- **Northern Goshawk.** The northern goshawk is a federal species of concern and a state candidate for listing. Northern goshawk has been documented within 1 mile of the site (USFWS, 2003; USFS, 2003); however, nesting status is unknown (USFS, 2003). Goshawks inhabit mature- to old-growth coniferous and mixed forests, and open woodlands. No mature or old-growth forests are present within the Habitat Assessment Area. Goshawks may occasionally pass through or forage in the Town of Skykomish.

- **Peregrine falcon.** Formerly classified as federally endangered, the American peregrine falcon was delisted in August 1999. The Washington State Status Report for the Peregrine Falcon (Hayes and Buchanan, 2002) notes the falcon is still listed as state endangered, but will likely be reclassified as sensitive in the future. No peregrine falcon nest sites are known to exist in the vicinity of the Town of Skykomish (USFS, 2003; USFWS, 2003; WDFW, 2003a).

- **Pileated woodpecker.** Pileated woodpecker is a Washington State candidate species and a USFS management indicator species. These woodpeckers are closely associated with mature and old-growth forests, using large diameter snags for nesting and roosting.

Late- and old-successional forests on the Mount Baker-Snoqualmie National forests provide high-quality habitat for pileated woodpecker. Because of the extent of timber harvest activity near the Town of Skykomish, and the lack of mature forested habitats at the site, use of the site by pileated woodpeckers is expected to be low. Occasional foraging may occur in snag in and around the Town of Skykomish.

- **Pacific Townsend's big-eared bat.** The Pacific subspecies of Townsend's big-eared bat is a federal species of concern, a USFS sensitive species, and a Washington State candidate for listing. The species is an insectivore that inhabits forested regions primarily west of the Cascade Mountains. Townsend's big-eared bats are primarily cavity-dwellers, typically selecting roost sites in caves or abandoned mines; they also use human-made structures such as barns, attics, and bridges, as long as human disturbance is very low (Pierson and Rainey, 1998). They require different sites with specific microclimatic conditions for roosting, hibernation, and reproduction. Caves have reportedly been used as maternal roost sites and hibernacula; bridges have also been documented as maternal sites (Fellers and Pierson, 2002).

  The status of Pacific Townsend's big-eared bat in the Skykomish vicinity is unknown; no occurrences have been reported (USFWS, 2003; WDFW, 2003a).

2.2.5.3 Threatened and Endangered Wildlife Species

The USFWS, USFS, and the WDFW provided information on federally listed, proposed, and candidate wildlife species and Washington State threatened and endangered species that may occur in the vicinity of the site. Three listed species of birds are known to occur in the general vicinity of the site. These species, bald eagle, marbled murrelet, and northern spotted owl, are discussed below. Three listed mammal species, Canada lynx, gray wolf, and grizzly bear, could potentially occur in the site vicinity; however, no suitable habitat for these three mammals is present in the site vicinity and no sightings of the species have been documented (USFS, 2003). These species are not expected to occur in the site vicinity (USFS, 2003; Stinson, 2001) and are not discussed further in this document. A summary of threatened and endangered species is given in Table 2-2.

- **Bald Eagle.** The bald eagle is a federal and state threatened species. Recovery efforts for the bald eagle have been successful in the lower 48 states, including the Pacific region. In 1999, the bald eagle was proposed for removal from the list of threatened and endangered species, as recovery goals had generally been met or exceeded (64 FR36543).

The South Fork Skykomish River basin is used by bald eagles primarily during the winter months when spawning salmon are available as a food resource. A winter concentration area is located approximately two miles west of the Town of Skykomish along a tributary to the South Fork Skykomish River (USFWS, 2003). Another area of regular winter use by foraging bald eagles is located about a mile northeast of the Site along a tributary river (USFS, 2003).

Bald eagles may roost communally near feeding areas during the winter months. Roost sites are often located in mature or old-growth forest stands in close proximity to feeding areas. A communal night roost is located about one mile west of the Town of Skykomish (USFWS, 2003; WDFW, 2003a).

Bald eagles occasionally use of the South Fork Skykomish River in the vicinity of the Town of Skykomish (USFS, 2003). Few suitable perch trees are present along this reach of the river, and use of the shoreline is limited. The majority of trees along the riverbank and the flood control levee are red alder and big-leaf maple of about 5 inches in diameter (maximum). These trees are not of suitable diameter and height to support bald eagles or to provide good visibility of the river. Bald eagles are reported by the Skykomish Environmental Coalition to commonly perch in trees along the north shoreline west of 5th street, especially during December and January.

There are no bald eagle nest sites within the Site vicinity (WDFW, 2003a; USFS, 2003).

- **Marbled Murrelet.** The marbled murrelet is a federal and state threatened seabird that nests in old-growth coniferous forests. Suitable habitat for marbled murrelet is present in the South Fork Skykomish River basin, primarily within unlogged stands of Douglas fir and western hemlock. In the Project vicinity, critical habitat for marbled murrelet has been designated within Late Successional Reserves (LSRs) designated under the Northwest Forest Plan (USFWS and USDI, 1994 as amended) for the management of northern spotted owl and other old-growth species including marbled murrelets. The LSRs occur exclusively on National Forest System lands.

  No records of marbled murrelet detections were present in the WDFW or Forest Service databases. Few, if any, surveys have been conducted in the Skykomish vicinity (USFS, 2003; WDFW, 2003a). Suitable murrelet habitat is not present within one-half mile of the Town of Skykomish (USFS, 2003).

- **Northern Spotted Owl.** The northern spotted owl was federally listed as threatened in Washington, Oregon, and California in July 1990 (55 FR 26114); it is a Washington State endangered species. Factors that contributed to the federal listing were the declining population trends, the loss of suitable forested habitats throughout the species range, and the lack of adequate regulatory mechanisms to protect existing habitat for the species.

  Competition with barred owls may be a factor in the population decline of spotted owls; barred owls have become common in some parts of the Washington Cascades and may outcompete spotted owls for nest-sites and prey in areas where mature and old-growth forests have been fragmented by timber harvest (Dark *et al*., 1998, Herter and Hickes, 2000). Fragmented forest stands with openings in the forest canopy, such as result from clear-cutting and thinning, promote use by great horned owls, a major predator of spotted owls (Johnson, 1993).

  Spotted owls are strongly associated with mature and old-growth forests for nesting, foraging, and roosting. Nesting and roosting occur in coniferous forests characterized by moderate to high levels of canopy closure, high density of standing snags, large diameter overstory trees with deformities such as broken tops and witches' brooms, and abundant coarse woody debris on the forest floor (USDI Fish and Wildlife Service, 1987). Foraging occurs in nesting and roosting habitat, and in coniferous forest of younger age and less structural diversity, where key prey species are present. Important forage species of spotted owls in mesic Douglas-fir forests include northern flying squirrel and woodrat species; these species occur at relatively low density and the spotted owl has a correspondingly large home range (USDI Fish and Wildlife Service, 1992).

  Critical habitat was designated for the northern spotted owl in 1992 (57 FR 1796). In the project site vicinity, spotted owl critical habitat coincides with Forest Service Late Successional Reserves, all of which are located on National Forest System lands.

  The WDFW database shows three spotted owl activity centers representing established territories in the vicinity of the Town of Skykomish (WDFW, 2003a). The site centers of all three territories are over two miles from the edge of town; none of the sites have been surveyed in recent years and the status of the sites is unknown (USFS, 2003). Suitable habitat for spotted owl does not occur closer than one-half mile from the edge of town (USFS, 2003).

It is possible that spotted owls, if present in the basin, could use forested habitats to the north of the South Fork Skykomish River or to the south of Maloney Creek. No habitats within the site are suitable for use by spotted owl.

2.2.6 Fish and Aquatic Biota

This section describes the fish and aquatic life in the water bodies in Skykomish. It includes information on the habitat diversity and threatened and endangered species of fish and aquatic biota.

2.2.6.1 Habitat Diversity

The obvious habitats for fish and aquatic biota at the site are the South Fork Skykomish River and the former Maloney Creek channel, which are described below. It should be noted that aquatic habitat and fish populations in the Snohomish Basin (including the South Fork of the Skykomish River) may be limited by natural low-flow conditions. These conditions typically occur in the summer months.

South Fork of the Skykomish River

The South Fork Skykomish River channel immediately below the Skykomish River Bridge ranges from approximately 150 to 250 feet wide. The channel gradient in this area averages approximately 27 feet per mile. The channel contains mostly glide habitat, with occasional riffles at lower flows. Larger sections of riffle are present approximately 2,900 feet downstream of the existing levee. Substrate within the channel varies in size from large boulders and cobbles to smaller gravels and sands. Larger boulder substrates are more frequent along the northern portions of the channel, with smaller cobbles, gravels, and sands occurring on a gravel bar adjacent to the southern shore.

Low-velocity shoreline habitat, which provides refuge for migrating juvenile salmonids, is present along the base of the existing levee throughout much of the site. The larger riprap and boulders present along this shoreline reduce flow velocities near the bank by creating eddies where water flows around these larger substrates. Low-velocity areas are also present within the interstices of the larger boulders and riprap.

However, natural low flows within the Snohomish River basin, particularly during the summer months, may limit fish access to low-velocity shoreline habitat areas. These natural low flows may also limit access to pockets of spawning gravels, while also potentially dewatering redds.

Overhanging vegetation present along the shoreline offers refuge from predators for juvenile fish, while helping to reduce water temperatures and increase water quality. In addition, overhanging vegetation provides a food source for juveniles through the deposition of detritus, which is a primary food source for aquatic insect larvae.

Aquatic habitat features present near the site include boulder substrates that provide refuge from high flows, large woody debris that provides refuge from predators, and large holding pools for migrating fish. The Biological Assessment being prepared for the project will describe the aquatic habitat present in the South Fork of the Skykomish River in greater detail.

Former Maloney Creek Channel

The culvert that connects to the segment of the former Maloney Creek channel (wetland) downstream of 5th Street is passable to adult salmonids during flowing periods, as they have been observed at various locations upstream of the culvert (Ecology, 2002b). The channel within the wetland adjacent to the railyard is undefined throughout most of its length, with surface sediment layers dominated by sands and silts overlain with varying amounts of organic debris. Ponding occurs throughout this area. The wetland contains several aquatic habitat features including an invertebrate food source and shading provided by dense canopy cover. Canopy vegetation is dominated by second-growth deciduous trees.

As mentioned above, the Biological Assessment being prepared for the project will discuss the aquatic habitat near the site in more detail.

2.2.6.2 Threatened and Endangered Species

Historically, Sunset Falls presented a barrier to the upstream migration of anadromous fish in the South Fork of the Skykomish River. Anadromous fish access to the upper South Fork has only been possible since 1952, when a trap and haul operation was commenced by the Washington Department of Fisheries at Sunset Falls (DEA, 1999).

Two threatened or endangered species of fish occur in the South Fork of the Skykomish River: Puget Sound chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*). Juvenile chinook would be expected to be present within the South Fork of the Skykomish River near the Town of Skykomish from mid to late February through May. Juvenile bull trout rear in their natal headwater streams, and are not expected to be present within the South Fork. As mentioned above, water levels within the South Fork at this time are such that the shoreline edge habitat is available to juvenile salmonids.

This section only describes Threatened and Endangered species. Coho, a federal candidate species, is discussed below in the section entitled Other Fish.

Chinook

Puget Sound chinook salmon are listed as threatened by the National Marine Fisheries Service (NMFS). They utilize the South Fork of the Skykomish River for spawning, migration, and rearing from the confluence with the North Fork Skykomish River, up to Sunset Falls (WDFW and WWTIT, 1994). Spawning in the upper South Fork basin occurs in suitable mainstem reaches, as well as the lower reaches of larger tributaries, including the Miller, Beckler, Tye, and Foss Rivers (Pentec and NW GIS, 1999).

Chinook life history, presence, and habitat use in the South Fork of the Skykomish River will be discussed in more detail in the Biological Assessment being prepared for the project.

The chinook stock present within the South Fork of the Skykomish River basin is the Bridal Veil Creek fall chinook, which typically spawn from late September through October (USFS, 1999). Juvenile emergence occurs from February to mid-March (Pentec and NW GIS, 1999). Chinook rear in freshwater habitats from several months to a year before emigration.

As described in Section 2.2.2, the substrates within the South Fork of the Skykomish River near the site are dominated by cobbles, with larger cobbles and boulders also present; therefore, large areas of suitable chinook spawning habitat is not likely to be present. However, small pockets of spawning gravels may be present near the site. The nearest large spawning riffle for Chinook is located approximately 2,900 feet downstream of the site. Overhanging riparian vegetation, which is present along the existing levee, provides many important habitat functions for juvenile salmonids (Meehan et al., 1977). Particularly, it increases the quality of the low-velocity shoreline edge habitat for juvenile salmonids by providing refuge from predators, decreasing water temperatures, and increasing production of food resources.

As mentioned in Section 2.2.2, low-velocity river margin areas are present along the base of the levee, containing areas of deeper water adjacent to the shoreline. Flows within the South Fork are typically high enough for juvenile salmonids to utilize this habitat from September to July. In July, the flows decrease to the point where the shoreline edge habitat is dewatered. However, at that time it would be expected that any juvenile salmonids still present would be large enough to occupy areas within the mainstem with higher velocities.

Shoreline edge habitat consisting of larger riprap and boulders offers rearing and refuge habitat to juvenile salmonids, including chinook (Pentec and NW GIS, 1999). The larger substrates slow water velocities near the margins of the streams, allowing juveniles to use these areas for refuge from both high flows and predation, as well as sources of food (Pentec and NW GIS, 1999).

Bull Trout

Bull trout are also listed as threatened by the NMFS. Bull trout in the upper South Fork of the Skykomish River basin exhibit three life history strategies: anadromous (migratory between saltwater and freshwater), fluvial (migratory within river systems), and resident (non-migratory). Bull trout present near the Town of Skykomish are predominantly anadromous, and utilize the South Fork as a migratory corridor, traveling upstream to spawning grounds on the lower East Fork Foss River. However, fluvial and resident bull trout may also be present near the site. Bull trout are opportunistic feeders that prey on a wide variety of organisms. Juveniles utilize terrestrial and aquatic insect larvae, zooplankton, amphipods, and various other invertebrates as a food source. Adults and sub-adults typically feed on juvenile salmonids, sculpin, and whitefish.

Bull trout require cold, clear water and loose, clean gravels for spawning, and prefer habitat with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (WDFW, 1997b). Spawning reaches must contain clean gravels over larger cobbles, with a very low quantity of fines. Bull trout spawning typically occurs from late August through early November, commencing when water temperatures drop below 46 ^{o}F (WDFW, 1998). Preferred bull trout spawning habitat is not likely to be present in the South Fork of the Skykomish River or the former Maloney Creek channel.

Fry typically emerge from the gravel from January through March and April, with juveniles remaining close to their natal headwater areas while rearing (Pentec and NW GIS, 1999). Anadromous bull trout generally leave headwater areas as 2-year olds and migrate to estuarine waters during the spring. During this migration, bull trout are large enough that they do not depend on the low-velocity river margins present within the South Fork.

In addition to bull trout, Dolly Varden (*Salvelinus malma*), a closely related species, may also be present near the site. Dolly Varden exhibit the same life history strategies and habitat requirements as bull trout (WDFW, 1998).

As mentioned above, bull trout life history, presence and habitat use in the South Fork of the Skykomish River will be discussed in more detail in the Biological Assessment being prepared for the project.

Other Fish

There are several other species of fish that may occur in the upper South Fork of the Skykomish River, including coho (*O. kisutch*), pink (*O. gorbuscha*), and chum (*O. keta*) salmon, steelhead (*O. mykiss*) and coastal cutthroat trout (*O. clarki clarki*), pacific lamprey (*Entosphenus tridentatus*), river lamprey (*Lampetra ayresi*), and mountain whitefish (*Prosopium williamsoni*). These species are not listed as threatened or endangered.

The juveniles of the salmonid species would be expected to utilize the shoreline edge habitat of the South Fork of the Skykomish River upon emergence. Juvenile coho, pink, and chum salmon typically emerge from the gravel from late February and early March through April and May. The low-velocity shoreline edge habitat of the South Fork would be used by these species. However, pink and chum generally migrate to estuarine waters immediately after emergence, and would likely only be present for a very short period.

The following describe these other salmonids. Table 2-3 summarizes salmonid presence and timing within the South Fork of the Skykomish River near Skykomish, as well as the former Maloney Creek channel.

- **Coho Salmon**. Coho utilize the South Fork as migratory, rearing, and spawning habitat, generally spawning from late October through January (Pentec and NW GIS, 1999). Coho spawning grounds include appropriate areas of the mainstem South Fork, as well as the lower reaches of Miller, Beckler, Foss, and Tye Rivers. Coho have also been observed in Maloney Creek (White, 2003). They typically prefer spawning habitat similar to chinook; as such, coho spawning habitat is unlikely to be present within the South Fork near Skykomish.

  Coho generally emerge from the gravel from March through May (Pentec and NW GIS, 1999). As with chinook, they would likely utilize the low-velocity shoreline habitat in the South Fork of the Skykomish River from March until June and July while migrating downstream in search of appropriate off-channel rearing habitat.

  The former Maloney Creek channel area contains small, quiet pools with large amounts of organic detritus, which likely offer quality rearing habitat for coho. Coho have been observed in the former Maloney Creek channel, as well as in the main channel of Maloney Creek (Ecology, 2002b).

- **Pink Salmon**. Pink salmon spawn in the upper South Fork basin from mid-September through October in odd-numbered years only, utilizing the mainstem South Fork as well as the Beckler River (Pentec and NW GIS, 1999). Pink salmon have also been documented in Maloney Creek (White, 2003). Pink salmon generally prefer smaller cobbles and gravels for spawning, and therefore would not likely spawn near the site.

  Pink salmon fry emerge from the gravel in March through April, and immediately begin their migration to estuarine waters. Pinks generally only reside in fresh water for 1 to 2 weeks, depending on the length of their seaward migration (Pentec and NW GIS, 1999).

However, they may occasionally utilize river shoreline edge habitat for rearing during their migration.

- **Chum Salmon**. Chum salmon are known to spawn in the mainstem Skykomish River as far upstream as Gold Bar (Pentec and NW GIS, 1999). Chum salmon in this area generally spawn from mid-November through mid-January. Spawning information for the upper South Fork of the Skykomish River is scarce, but adult chum have been recorded in the lower reaches of Maloney Creek (Ecology, 2002b). Chum likely spawn in appropriate mainstem reaches along the South Fork of the Skykomish, as well as the lower reaches of larger tributaries. Because of their larger size, chum have similar spawning habitat requirements as chinook. As such, suitable spawning habitat for chum is not likely to be present in the vicinity of the site area.

  Chum fry emerge from the gravel in the spring, usually from February and March into May (Pentec and NW GIS, 1999). As with pink salmon, chum typically do not rear in freshwater, usually residing in freshwater for only a couple of weeks. Limited use of South Fork mainstem rearing habitat may occur during their estuarine migration.

- **Steelhead**. Steelhead use the upper South Fork basin and its tributaries for spawning, rearing, and migration. Summer steelhead spawn from February to April in the lower reaches of Miller, Foss, and Tye Rivers, while winter steelhead spawn from early March to early to mid-June in the lower reaches of Miller, Beckler, and Foss Rivers (Pentec and NW GIS, 1999). Steelhead prefer fast-moving, higher gradient reaches with larger substrates for spawning (WDFW, 1997a). Therefore, the habitat present within the South Fork near Skykomish likely does not contain suitable spawning habitat for steelhead.

  Juvenile steelhead typically emerge from the gravel from June through August. Juvenile steelhead primarily utilize mainstem habitat for rearing, typically overwintering for two or more years before emigrating to saltwater (Pentec and NW GIS, 1999). They prefer fast-moving water with larger substrates for rearing, utilizing the areas behind larger cobbles and boulders (WDFW, 1997a). As their emergence time generally corresponds with lower flows and dewatering of the shoreline edge within the South Fork, steelhead likely utilize this habitat for only a short period of time before moving to faster waters.

- **Coastal Cutthroat Trout**. Anadromous coastal cutthroat trout are generally not found above the town of Gold Bar in the Skykomish River (WDFW, 2000). Coastal cutthroat typically prefer slower-moving, lower-gradient streams, and therefore would not likely be found in the mainstem South Fork Skykomish River near the site (Pentec and NW GIS, 1999).

  Fluvial cutthroat trout may be present in limited numbers within the mainstem South Fork and Maloney Creek (WDFW, 2000). Fluvial cutthroat present in mainstem rivers generally migrate upstream to spawn in smaller tributaries and side channels. Fluvial cutthroat in the Snohomish Basin spawn from January through mid-June. Juveniles emerge from the gravel within eight to nine weeks, and generally seek out slow-moving side channels and tributaries (WDFW, 2000).

In addition to the salmonids described above, several other species of fish may be present near the site. Pacific lamprey and river lamprey are both listed as Federal Species of Concern, with river lamprey also listed as a State Candidate species by WDFW (WDFW, 2003c). Both species spawn in gravel in clear streams, with ammocoetes developing in mud, silt, and sand substrates at the bottoms of pools and backwater eddies. In addition, mountain whitefish (*Prosopium williamsoni*), which is listed as a State Species of Concern, may also be present near the site (WDFW, 2003c). Mountain whitefish prefer fast, clear or silty streams, feeding primarily on aquatic insect larvae, mollusks, fish, and fish eggs (Froese and Pauly, 2003).

2.3 Built Environment

This section describes land use plans, historic resources, public services, environmental health considerations, and transportation. The town and site are described in Section 2.1.

2.3.1 Land and Shoreline Use Plans

This section describes how the Town of Skykomish is zoned in the subsection called Zoning Ordinances. It also describes the CAO, which includes information on shoreline use. Finally, this section describes the housing and demographics of the Town of Skykomish and the aesthetic and historical structures.

2.3.1.1 Zoning Ordinance

The Town of Skykomish is a rural town and is surrounded on all sides by the Mt. Baker-Snoqualmie National Forest. It is divided into five zoning districts: residential, commercial, industrial, historic commercial, and public (Ordinance 235, 1995). The industrial zone of Skykomish consists of the railyard. There are commercial zones on the north bank of the South Fork of the Skykomish River and south of the railyard. The Town of Skykomish has designated a Historic Commercial Zone north of the railyard.

The remainder of the town is residential with the exception of the public buildings, such as the school, community center, and town hall. There is a public park outside of the city limits on the north side of the South Fork of the Skykomish River, as described below.

The majority of businesses in Skykomish are small retail but also include gas stations, motels, and hotels that cater to local residents and tourists (Town of Skykomish, 1993). Besides the BNSF railroad maintenance activities, there is no other industry in Skykomish. The National Forest Service maintains a depot in Skykomish.

The site includes land in each of the five zoning areas, as shown on Figure 2-16. The site includes the historic commercial zone in the downtown area, most of the industrial zone, and most of the public zone. The site covers approximately 230,000 square feet of residential land.

2.3.1.2 Critical Areas Ordinance

A CAO (Ordinance 269, 1998) for the town was adopted by the town council in 1999. The CAO was adopted to designate and classify environmentally sensitive and hazardous areas, including wetlands, fish and wildlife habitats, flood hazard areas, geologic hazard areas, and aquifer recharge areas. The CAO regulates alterations in and adjacent to critical areas to protect natural resource values, public resources and facilities, and public safety. The CAO also meets the requirements of the Washington Growth Management Act (RCW 36.70A) with regard to the protection of critical areas and the Shoreline Management Act (RCW 90.58) with regard to protecting shorelines. The CAO is used to coordinate environmental review and permitting of proposed actions affecting critical areas.

Areas protected under the CAO include the former Maloney Creek channel and wetland, Maloney Creek, and the South Fork of the Skykomish River. The South Fork of the Skykomish River and Maloney Creek meet the definition of Primary Fish and Wildlife Habitat. The former Maloney Creek channel and wetland are ranked for this evaluation as secondary fish and wildlife habitats, based on the absence of documented federal and/or state-listed species. The former Maloney Creek channel and wetland are shown on Figure 2-1. The site of the South Fork Skykomish River is considered a "shoreline of statewide significance" with the receipt of water from Beckler Creek, just upstream of the town (WAC 173-18-20).

Areas within the 100-year floodplain are defined as Flood Hazard areas under the CAO. The 100-year floodplain associated with the South Fork Skykomish

River and Maloney Creek may be seen on Figure 2-9, and is discussed in more detail on Section 2.2.2 under the title "Floods."

The CAO is also the primary regulation applicable to management of activity in and around shorelines. The requirements of the CAO must be met in order to receive a Shoreline Conditional Use permit, a Shoreline Substantial Development permit, or a Shoreline Variance.

2.3.1.3 Housing and Demographics

The majority of housing units in Skykomish are single-family residences (U.S. Census Bureau, 2001). Twenty-six residences lie within the footprint of the site. Some of the residences in Skykomish are mobile homes and approximately one-third of these are used as seasonal residences. The commercial buildings are predominantly small retail but also include gas stations, a church, motels, and hotels that cater to local residents and tourists (Town of Skykomish, 1993). There are 10 commercial buildings on the site.

The most recent census (U.S. Census Bureau, 2001) reports 214 people living in Skykomish of which 29 (13 percent) are under the age of 19. It is estimated that up to 30 seasonal residents live in Skykomish at any time of the year (Dohran, pers. comm., 2003). The decline of the railroad as a primary form of transportation resulted in the loss of railroad-related jobs in Skykomish. Now the school is the major year-round employer in Skykomish. Since automotive use has increased, residents of Skykomish have been able to commute to major employment centers and Skykomish has become more accessible to seasonal residents and visitors. The economy of Skykomish is now dependent on tourism and the USFS (Town of Skykomish, 1993).

2.3.2 Historical and Cultural Resources

The Town of Skykomish includes areas, structures, and buildings listed on the National and State Registers of Historic Places, and contains an area zoned by the Town of Skykomish as Historic Commercial. The Historic Commercial zone lies mainly to the north of the railyard and is defined differently by the National Register of Historic Places and an Interlocal Agreement for landmark services between the Town of Skykomish and King County (both are shown on Figure 2-17). The Town of Skykomish Zoning Ordinance #235 encompasses all areas covered by the national and local historic designations. The National Register of Historic Places is defined as Railroad Ave., from 3rd Street to west of N 6th Street, and part of Old Cascade Hwy. The National Register designation includes 12 buildings and the Skykomish Bridge as well as the Skykomish Masonic Hall along Old Cascade Highway. Prior to the national designation of the Skykomish Historic Commercial District, the Great Northern Depot and Maloney's General Store were listed separately in the National Register of Historic Places. The local designation includes 12 buildings as well but does not include the bridge.

Several of the cleanup alternatives require moving historic buildings temporarily to allow for excavation beneath them. The buildings would then be returned to their original sites in such a way that the rail-oriented configuration of lots and buildings, streetscape and location of buildings relative to the street are maintained. The Secretary of the U.S. Department of the Interior has issued Standards for the Treatment of Historic Properties. These Standards do not 'apply' to the cleanup action because there is no grant-in-aid involved (see 36 CFR Part 68), however, these Standards are 'relevant and appropriate' under MTCA to the extent the cleanup will affect historic buildings, sites, structures or districts. Potential impacts to historic resources that may result from temporary relocation might include loss of landscape features, movement or setline of buildings, and some changes of surface grade, for example. These impacts are evaluated in the Draft EIS and will be further addressed, including any necessary mitigation measures, in the Final EIS.

To respond to public and agency comments on the Draft FS and Draft EIS, and to further document historic resources in Skykomish, BNSF retained a Historical and Cultural Resources Specialist to expand the descriptions of the various designations and districts in accordance with industry practices. BNSF is also conducting an archaeological survey of the project area at the request of Ecology and the Washington State Office of Archaeology and Historic Preservation. The results of this work will be presented in the Final EIS.

2.3.3 Public Services

This section describes the public services that the Town of Skykomish provides to its citizens. These include schools, parks and recreation, and utilities. In addition, Skykomish provides the following services:

- Fire fighting services through a contract with King County Fire District No. 50

- Police protection through a contract with the King County Sheriff (Yates, 2003b)

- Road maintenance including snow plowing and repairing of road surfaces (Yates, 2003b).

The nearest hospital to Skykomish is approximately 40 miles away in Monroe, Washington.

2.3.3.1 Schools

There are no private or charter schools in Skykomish. The Skykomish Elementary and High Schools of School District 404 are located at 105 Sixth Street (Figure 2-16). There are 70 students enrolled in grades K-12 for the

2002–2003 school year. In general, the enrollments of the Skykomish Schools are decreasing. The School District stretches from Index in Snohomish County to the eastern side of Stevens Pass. School buses bringing students to school enter the Town of Skykomish on 5th Street, take a right on Railroad Avenue, and then a right onto 6th Street. The buses turn left at the three-way intersection at the end of the block and turn around (Moore, 2003).

2.3.3.2 Parks and Recreation

Skykomish has one small community park that is south of U.S. Highway 2 and north of the South Fork of the Skykomish River. Access to the park, which includes a baseball diamond, lies approximately half a mile east of the 5th Street Bridge over the South Fork Skykomish River. In addition, there is a small park, the Depot Park, located at the intersection of 5th Street and Railroad Avenue. Other nearby recreational facilities include the South Fork of the Skykomish River and neighboring National Forest lands. There are no trailheads or camping grounds within the Town of Skykomish limits nor is there public access to the river on or near the site, although the public can access the river using a path just north of the Skykomish River Bridge across the South Fork Skykomish River.

2.3.3.3 Utilities

There are no municipal storm or sanitary sewer systems or wastewater treatment plants in Skykomish. Residents use septic systems consisting of tanks and leach fields to treat and dispose of sanitary waste. The people of Skykomish are served by two public water supply wells that are located about 1,100 feet east (upgradient) of Skykomish, as discussed in Section 2.2.2.

2.3.4 Environmental Health

In this section describes how the built environment of the Town of Skykomish could affect environmental health. Noise, vibrations, and hazardous substances are all factors that could affect environmental health.

2.3.4.1 Noise

Noise can be defined as unwanted sound that is disturbing or annoying. Sound can be objectionable due to pitch or loudness. Pitch depends on the frequency of vibrations that produce the sound. Loudness is the intensity of sound waves. Decibels (dB) measure the relative amplitude of sound. The decibel scale is logarithmic, meaning that an increase of 10 decibels is a ten-fold increase in acoustic energy. The A-weighted sound level (or dBA) gives greater weight to sound frequencies to which the human is ear is more sensitive, as shown on Figure 2-18. Table 2-4 gives descriptions of different levels of sound. Since environmental sounds are often made up of time-varying events, most environmental sounds are described using an average level that has the equivalent acoustical energy as the summation of all the time-varying events.

Noise attenuates in the atmosphere as a function of distance between the receiver and the source. Typically noise is reduced 6 dB for every doubling in distance. Additionally noise is attenuated by intervening structures.

The two main sources of noise in Skykomish are the BNSF railroad that passes through town and traffic along U.S. Highway 2. Stationary idling locomotives exceed 85 dB (the occupational limit) at 30 feet (Union Pacific Railroad, 1999) while a train traveling 30 to 40 miles per hour produces 88.7 dB of noise at a distance of 100 feet (RETEC, 2003c). Approximately 24 trains pass through Skykomish on average each day, but do not regularly stop and idle in town.

2.3.4.2 Vibrations

Train traffic passing through Skykomish is the only significant source of vibrations on a regular basis.

2.3.4.3 Hazardous Substances

The most significant risk of explosion or new releases to the environment on the site is an accident on the railroad or highway. There is an existing potential of exposure to hazardous substances from the subsurface contamination that is being addressed in this Final FS. In addition, heating oil is used throughout the town and is stored in underground storage tanks throughout the town. The school also has a diesel boiler.

2.3.5 Transportation

This section describes roads, transportation systems, and traffic through Skykomish.

2.3.5.1 Roads and Transportation Systems

There is no public transportation within Skykomish or to Skykomish. U.S. Highway 2 is a federal highway. U.S. Highway 2 goes west from Skykomish to Everett, Washington, and east from Skykomish to Chelan, Washington. Figure 1-1 shows U.S. Highway 2 and Figure 2-16 shows roads in the town.

The Washington State Department of Transportation (WSDOT) maintains the steel truss bridge into town from U.S. Highway 2. The bridge is 102 feet long with 10 feet of clearance (Department of Highways, 1938). There are no posted load restrictions on the bridge.

There are about 3.3 miles of local roads composed predominantly of asphalt concrete in Skykomish (Town of Skykomish, 1993).

2.3.5.2 Traffic

The average annual daily traffic count for U.S. Highway 2 north of town is approximately 4,750 vehicles (Taylor, 2003). There is limited traffic within Skykomish itself and there are no traffic lights.

2.4 Interim Cleanup Actions and Ongoing Site Maintenance

This section describes the interim cleanup actions and ongoing maintenance of them at the site.

2.4.1 Barrier System

In August 2001, a barrier system was constructed along the West River Road at the site. The barrier system consists of a 600-foot cement-bentonite slurry wall constructed to a depth of 15 feet bgs, and recovery wells. The purpose of the barrier system is to contain and recover free product migrating to the South Fork Skykomish River. Free product was present within the levee downgradient of the wall when the barrier system was installed and is being recovered to extent feasible with booms and pads, as described in Section 2.4.2. The barrier wall and booms are not designed to contain all hydrocarbons dissolved in groundwater.

The wall is positioned along West River Road adjacent to the levee. This location was selected to intercept oily seeps and thereby minimize risk to human health and the environment. The length and configuration of the wall is based on the location of product seeps and the free product plume. Because the wall alignment is not perpendicular to the groundwater flow direction, wing walls were constructed for extra protection against free product flow around the downgradient end of the wall and to enhance product recovery throughout the recovery zone (area immediately upgradient of the wall). The barrier wall extends deeper than historical low water levels of about 10 feet bgs. This ensures containment of free products but is not designed to capture petroleum dissolved in groundwater that may migrate beneath and around the wall.

Recovery wells have been installed upgradient from the barrier wall. These wells are screened across the water table and are 6- or 8-inch diameter, stainless steel wells with a 20 slot wire-wound screen. These have been gauged on a monthly basis and skimmer pumps have been installed and are operational in those wells in which free product has been accumulating. The free product is pumped from the wells into subsurface vaults. These vaults are evacuated, as necessary. Figure 2-19 shows the configuration of the recovery wells and barrier wall. The free product between the river and the barrier wall was there prior to the barrier wall construction. This is an ongoing source of free product to the river and is being recovered to extent feasible with booms and pads, as described in Section 2.4.2. Further details are provided in the *Interim Action Completion Report* (RETEC, 2001). *Phase 2 Interim Action Completion Report* (RETEC, 2003d), and in BNSF's monthly progress reports to Ecology.

2.4.2 Oil Recovery Booms

Seeps of free product have been observed on the southern bank of the South Fork of the Skykomish River downstream of the Skykomish Bridge. The source of these seeps is free product that was present downgradient of the barrier wall when the barrier system was installed. The oil seeps consist of a dense, thick, heavyweight product with a viscosity similar to bunker C fuel oil. The specific gravity is slightly less than one, thus the product is present at the water surface. Product has been observed in the form of sheens or occasional globules up to 0.5 inch in diameter seeping out of the riverbank with groundwater. To mitigate such seeps while completing the RI/FS, BNSF implemented the boom deployment and mitigation program, described in the Interim Action Plan (RETEC, 1995) and *Boom Maintenance Technical Memorandum* (RETEC, 2002b). Boom deployment and maintenance supplements the oil recovery system and subsurface barrier wall. The current boom maintenance program entails placing oil-absorbent booms along the riverbank year round at the seep locations. These booms are inspected regularly and are replaced, as needed. Single or multiple rows of boom have been used for the free product recovery. In addition, LNAPL is recovered from the water behind the boom and from the seep on the river bank using pom-pom booms and oil-absorbent pads. Further details are provided in the *Boom Maintenance Technical Memorandum* (RETEC, 2002b) and in BNSF's monthly progress reports to Ecology.

2.4.3 Dust Suppression Application

Currently, the dust suppressant Soil Sement® is being applied annually at the site to control dust and erosion. Soil Sement® is an environmentally safe non-hazardous polymer emulsion that bonds surface dust and aggregate together into a hard, dust-free, and water-resistant surface. The sealant is applied to reduce dust generation from areas of the railyard that contain elevated concentrations of lead and arsenic. The purpose of the interim action of applying the sealant is to minimize human environmental exposure to the contaminants (lead, arsenic) through direct contact and windblown dust. A map that shows the extent of metals impacts on the railyard has been provided to BNSF workers, and during routine track maintenance activities care is taken to avoid excessive disturbance of the areas potentially impacted by lead, arsenic and PCBs.

3 Nature and Extent of Contamination

This section describes the type of contaminants at the site (nature) and the distribution of these contaminants vertically and horizontally across the site (extent). The nature and extent of contamination was determined based on data collected for the RI and Supplemental RI.

Petroleum hydrocarbons are the most widespread and significant group of contaminants in the site. They are present throughout much of the site in soil, groundwater, and sediment. These have been tested for as TPH in the diesel and motor oil range throughout the site. In addition, the hydrocarbon composition and hydrocarbon constituent compounds have been tested from selected samples as polynuclear aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene and xylenes (BTEX); and extractable and volatile hydrocarbon fractions (EPH/VPH).

Plumes of free product extend from the railyard northwest to the South Fork Skykomish River (Figure 3-1). The free product plumes act as sources for soil contamination and for dissolved hydrocarbons in groundwater. Free product seeps are present in the South Fork Skykomish River adjacent to the upland plumes. Currently, the highest concentrations of TPH coincide with the locations of free product in soil and sediment. The extent of free product has been reduced over time by seepage into the South Fork Skykomish River, by attenuation processes such as biodegradation, and by removal during barrier wall construction and subsequent recovery wells along the barrier wall. The areas that typically formerly contained free product, now contain high concentrations of residual TPH and the soil is heavily stained with hydrocarbons. These areas still contain high concentrations of TPH in the soil and groundwater.

Metals, specifically lead and arsenic, are also contaminants within the site. The metals impacts are generally restricted to shallow soil on the railyard, although there are some elevated concentrations of lead in shallow soil on seven properties, including Town property, in the residential and commercial area north of the railyard.

Polychlorinated biphenyls (PCBs) have also been detected in soil at the site in a limited area. These are related to a former substation and transformers on the railyard. They are restricted to the shallow soil on the railyard.

The contamination across the site is present within similar lithologies; however, the methods that may be used to clean it up vary in different parts of the site because of surface constraints and differing cleanup requirements. Figures 6-2 through 6-6 in the Supplemental RI (RETEC, 2002) show the affected lithologies. These cross sections indicate that contamination is predominant within sand and gravel and does not extend far into the underlying silt. Site cleanup zones (Figure 3-2) have been developed for the site to facilitate development and description of remedial alternatives, and designate areas of the site that may be amenable to common treatment technologies. The site has been divided into zones based on land use (railyard, commercial, residential), land type (wetland, levee, upland) and TPH composition. Based on the above assessment, the following zones were created:

- **Aquatic Resource Zones –** Includes the South Fork Skykomish River, the levee and the former Maloney Creek channel.

- **Northeast Developed Zone –** Includes land that has been or will likely be developed for commercial or residential use and is affected by petroleum plume primarily composed of diesel fuel.

- **Northwest and South Developed Zones –** This includes land that has been or will be developed for commercial or residential use. The smear zone soil and groundwater have been impacted by plumes consisting of a mixture of diesel and bunker C, and isolated elevated concentrations of lead in surface soil.

- **Railyard Zone –** Includes land historically used for industrial purposes and portions of two immediately adjacent residential properties. The soil in this zone has been impacted by petroleum hydrocarbons (diesel and bunker C) in the surface, vadose and smear zone, and by lead, arsenic and PCBs in the surface soil. Some groundwater within the zone contains dissolved petroleum hydrocarbons and there are some areas with free product. This land is all owned by BNSF, except for the two residential properties that are owned by James W. Hawkins and Lorna M. Goebel.

The zones are further described in Section 6 and are referred to in the remainder of this section.

3.1 Soil Quality

Soil samples have been collected from locations throughout the site and have been analyzed for petroleum hydrocarbons (TPH-Dx, EPH/VPH, PAHs, and BTEX), lead, arsenic, PCBs and dioxins. The soil samples have been collected to support several site investigations; the most extensive soil investigations are reported in the RI (RETEC, 1996) and in the Supplemental RI (RETEC, 2002a). Details of the other investigations are provided in Section 2 of the Supplemental RI Report (RETEC, 2002a). The soil samples have been collected from several depth intervals ranging from the ground surface to approximately 20 feet below the ground surface. These depth intervals have been defined as the surface, vadose, smear and saturated zones, and are described below.

- **Surface Zone –** The surface zone has been defined as the upper 6 inches outside the railyard and the upper 2 feet in the railyard. This is the uppermost soil within the vadose zone; however, this uppermost interval has been designated as the surface zone to distinguish those impacts that do not extend far below the ground surface. The soil in this zone is unsaturated with groundwater at all times.

- **Vadose Zone –** The vadose zone is located between the surface zone and the smear zone. This zone is located above the water table under normal conditions and consists of unsaturated soil. Contaminants within this zone will migrate vertically downwards under the influence of gravity and will not be transported by groundwater flow. This zone varies in depth and thickness throughout the area. The top of the vadose zone always underlies the base of the surface zone. The base of the vadose zone corresponds to the maximum groundwater levels and the top of the smear zone. This depth averages approximately 4 feet north of the railyard and is approximately 10 feet in the vicinity of the railyard; as a result, the thickness of the vadose zone varies between 2 and 8 feet. In a few low-lying areas and close to the barrier wall, the base of the vadose zone may be as shallow as 2 feet below the ground surface or may even be absent because of high water levels that may intersect the ground surface.

- **Smear Zone –** The smear zone is defined as the range of depths within which the groundwater will fluctuate under normal seasonal conditions, and therefore, in which free product would move and "smear" the soil in response to these seasonal changes in the water level elevation. The smear zone soils may therefore be saturated or unsaturated with groundwater at any given time. In addition to groundwater fluctuations influencing contaminant migration, the contaminants may be transported laterally through the aquifer in the direction of groundwater flow by the movement of groundwater.

  The smear zone does not change seasonally but refers to a range of depths through which the groundwater table fluctuates seasonally. The top of the smear zone varies from a minimum depth of 2 feet near the barrier wall to a maximum depth of approximately 10 feet in the railyard. The base of the smear zone ranges from an approximate depth of 10 feet near the barrier wall and north of the railyard to a maximum depth of approximately 18 feet on the railyard. The thickness of the smear zone varies according to the groundwater elevation and the depth to groundwater; typically, it is 5 to 10 feet thick. In areas where the ground surface is much lower than the surrounding area, the smear zone is closer to the ground surface. The former Maloney Creek channel is an example of this. In the former channel, the depth to groundwater is typically very shallow and may actually be at the ground surface when the groundwater levels are high. Therefore, in the Maloney Creek area, the smear zone may extend to the ground surface

- **Saturated Zone –** The saturated zone is defined as the depths where groundwater is always present regardless of groundwater elevation fluctuations. This contrasts with the smear zone in which the soil is saturated with water for some of the year, and unsaturated for the remainder of the year. The top of the saturated zone is considered the base of the smear zone. Since free product floats on and near the water table, it does not enter the saturated zone. The base of the smear zone is the top of the saturated zone and occurs generally between 10 and 18 feet below the ground surface.

The positions of the vadose zone, smear zone, and saturated zone are shown on the schematic cross section shown in Figure 4-2. The smear zone is the zone outside the source area containing free and residual product.

3.1.1 Petroleum Hydrocarbons in Soil

Petroleum hydrocarbons are present within the surface zone, vadose zone and smear zone in parts of the site. Soil samples have been analyzed for TPH (as diesel and motor oil) using methods WTPH-D, NWTPH-Dx, NWTPH-D and EPA Method 418.1. In addition, fractionation data on specific carbon chain-length hydrocarbons were collected from samples at depth using EPH/VPH and selected soil samples have been analyzed for BTEX and PAHs.

3.1.1.1 Total Petroleum Hydrocarbons in Soil

The analyses show that TPH is present in the surface, vadose and smear zones within the railyard. The concentrations of TPH (diesel and oil) in vadose and smear zone soil are presented in Figures 7-2 though 7-6 of the Supplemental RI. In general, the surface and vadose zone impacts coincide with historical railroad operational areas that acted as sources of contamination, although some surface zone impacts were also caused by road asphalt. These operational areas included the fueling station and diesel tank, and areas topographically downgradient from the oil unloader pits, timber oil sump and oil pump house. Figure 3-3 presents the extent of petroleum hydrocarbons, measured as NWTPH-Dx, in vadose zone soil throughout the site.

TPH is more widespread in the smear zone. Figure 3-4 presents the extent of petroleum hydrocarbons, measured as NWTPH-Dx, in the smear zone soil throughout the site. Figures 3-3 and 3-4 have been revised since the data were presented in the Supplemental RI (RETEC, 2002a) to present NWTPH-Dx data (sum of diesel-range and oil-range hydrocarbons) and to ensure that the extent of contamination in the soil is consistent with the extent of TPH in groundwater and location of free product. In addition, Figure 3-4 has been revised to provide a conservative estimate of contamination for designing the remediation systems for the site.

In the smear zone, TPH is generally located in areas coincident with the vadose zone impacts and is hydraulically downgradient from those impacted areas. This reflects free product migration with groundwater downgradient (to the northwest) from the former operational areas. The maximum TPH concentrations are 78,000 mg/kg and 59,000 mg/kg in the vadose zone and smear zone, respectively (RETEC, 2002a – Table 7-2). No free product was present in the surface or vadose zone during the field sampling. The residual saturation in the vadose zone varies with differences in the lithology throughout the site. These data indicate that the residual saturation on the railyard may exceed 20,000 mg/kg. Soil in the saturated zone contains hydrocarbons at concentrations exceeding 20 mg/kg throughout much of the site, coincident with the smear zone, because the free product extends slightly below the water table. Therefore, the uppermost portion of the saturated zone may also be impacted with petroleum hydrocarbons. Figure 3-5 shows the estimated extent of petroleum hydrocarbons, measured as NWTPH-Dx in saturated zone soil.

The saturated zone samples (Table 7-4 Supplemental RI Report, RETEC, 2002) indicate that contamination has not been detected in soil more than 25 feet below ground surface. In addition, groundwater samples collected from wells (DW-1 through DW-5) completed below the silt have not contained detectable concentrations of hydrocarbons (RETEC, 1996). This indicates that the silt bed that underlies the site at approximately 15 to 25 feet is an effective barrier to vertical migration of contaminants.

3.1.1.2 Composition of Hydrocarbons in Soil

Diesel fuel and bunker C were historically used on the railyard. As such, the petroleum hydrocarbons present throughout the site consist of these two fuels in varying proportions. Soil was analyzed for diesel and bunker C using the NWTPH-Dx method. The NWTPH-Dx method reports TPH as diesel (C9 to C20) and oil (C20 to C32). Diesel fuel generally includes hydrocarbon ranges C9 to C20 whereas bunker C is a fuel mixture that generally contains both diesel range and oil range hydrocarbons (C9 to C32). Therefore, TPH-diesel analysis will provide the concentration of diesel fuel and/or the lighter hydrocarbons in bunker C within a sample, whereas TPH-oil will only provide concentrations of the heavier hydrocarbons present in bunker C. As a result the relative extents can be determined from the concentrations of TPH-diesel and TPH-oil; TPH-oil is used to assess the extent of bunker C only. Furthermore the ratio of TPH-diesel to TPH-oil indicates the relative proportions of diesel to bunker C within the samples. The diesel: oil ratio varies considerably throughout the site, indicating that the composition is not uniform; this is consistent with visual observations made during collection of the soil samples. These observations showed the product to be an emulsion (or immiscible combination) of bunker C and diesel. The geometric mean of the diesel: oil ratio for all soil samples is 1:1.3; however this ratio varies from a maximum of 10:1 to a minimum of 1:10. The ratio of diesel to oil also varies depending upon the depth from which the soil sample was collected. The geometric mean of ratios from the surface and vadose zones is 0.5, whereas the geometric mean of samples from the smear zone equals one. This indicates that there is relatively more diesel in samples below the high groundwater table than in the vadose zone. Diesel constitutes the lighter weight, more mobile hydrocarbons, and therefore this observation is not surprising.

3.1.1.3 Extractable and Volatile Petroleum Hydrocarbons in Soil

EPH/VPH samples have been collected from soil samples in the vadose, smear and saturated zones both inside and outside the railyard (RETEC, 2002a). These analyses indicate that the petroleum hydrocarbons consist mainly of C12 to C34 carbon ranges for aromatics and aliphatics; this is consistent with the diesel and motor oil range hydrocarbons present at the site and indicates that both diesel and bunker C are present in these samples. Further details of the hydrocarbon ranges detected in the soil samples are provided in Section 7.1 of the Supplemental RI (RETEC, 2002). A correlation has been developed between NWTPH-Dx and total EPH/VPH (Figure 3-6). The figure shows that a strong correlation exists between EPH/VPH and NWTPH-Dx in soil and that the reported concentrations of NWTPH-Dx will typically be approximately 1.24 times the concentration of total hydrocarbons measured using the EPH/VPH method.

3.1.1.4 Polynuclear Aromatic Hydrocarbons in Soil

PAHs have been reported in soil samples from the site; these are generally reported in the soil samples that contain the highest concentrations of TPH. These samples are in former source areas or in areas within the smear zone with free product or high concentrations of residual petroleum hydrocarbons. All PAHs that have been tested for have been detected in soil samples; the most widespread include acenaphthene, fluoranthene, fluorene and pyrene. Further details, including a more complete discussion of the results, are presented in Section 7.5 of the Supplemental RI.

3.1.1.5 Benzene, Toluene, Ethylbenzene, and Xylenes in Soil

BTEX compounds are not common constituents of the petroleum hydrocarbons, though low concentrations have been detected. The low BTEX concentrations are not surprising considering that the petroleum hydrocarbons used at the railyard are primarily composed of the heavier-end hydrocarbons, and that the releases occurred at least 30 years ago.

3.1.2 Metals in Soil

During initial investigations, arsenic and lead were identified as the primary metals of concern and are, therefore, the only metals that were subsequently investigated. Samples were collected primarily from surface zone soils; however, several samples were also collected from shallow subsurface soils.

3.1.2.1 Arsenic in Soil

Arsenic (Figure 3-7) is present at concentrations above MTCA Method A concentrations (20 mg/kg) on the railyard. The majority of samples with levels above 20 mg/kg were collected near current and former railyard facilities. The sources of arsenic in soil are not completely understood; arsenic is commonly associated with treated railroad ties and therefore the distribution may be associated with areas in which the ties were stockpiled. Arsenic is also frequently present in sandblasting grit, and therefore the arsenic may be associated with some historic sandblasting operations. Elevated arsenic concentrations have also only generally been detected within samples from the upper 2 feet of soil collected from the railyard. Only one deeper sample (MW-31 at 4 feet bgs) contained arsenic greater than 20 mg/kg; this sample contained arsenic at a concentration of 27 mg/kg.

3.1.2.2 Lead in Soil

Lead (Figure 3-8) is elevated above the site-specific background concentration of 24 mg/kg (as calculated in Appendix G) within some areas of the railyard that coincide with historical railyard operations. On the railyard, elevated lead concentrations coincide with historical operations. The potential sources of lead include sandblast grit, leaded-fuel train exhaust and paint. The maximum lead concentration (3,600 mg/kg) was detected in a surface sample (B-9) from the railyard. Within the railyard, lead concentrations are elevated in the surface soil only. Elevated lead concentrations are present in sporadic surface soil samples from outside the railyard; the sources of this lead are unknown. See Section 4.2.1 for additional details.

3.1.3 Polychlorinated Biphenyls in Soil

Low concentrations of PCBs are present near the former transformer pads on the railyard (Figure 3-9). The PCBs are localized in extent and have not been detected anywhere other than close to the site of the historic transformer pads on the railyard. Further details are provided in the *Supplemental RI Report* (RETEC, 2002a).

3.2 Free Product

This section describes the nature and extent of free product. The movement of free product via groundwater through soil is described in Section 4.2.3.

3.2.1 Physical Properties of Free Product

The predominant types of product used or stored at the railyard were historically bunker C and diesel. Fortnite oil (a kerosene-like product) was reportedly used as a cleaning solution during repair activities that occurred at the maintenance yard from the 1890s to the mid-1940s. In addition, gasoline, and waste oil have been used and stored on the railyard. Free product samples collected at the site are characterized as a mix of diesel and bunker C fuel, consistent with the predominant product types used on the site.

Bunker C is usually blended with lower-molecular-weight fractions, such as diesel, to decrease viscosity and improve flow characteristics. The groundwater contains 43 to 49 percent petroleum hydrocarbons in the diesel range, with the exception of MW-39, which contains approximately 21 percent petroleum hydrocarbons in the diesel range. The free product in well MW-39 consists primarily of bunker C fuel with little, if any, diesel.

Product characteristics have been determined by laboratory analysis of four product samples collected at the site (RETEC, 1996 – Table 6-11). These samples comprise a mixture of diesel and bunker C. The nature of the hydrocarbons in the samples was evaluated using Washington Method WTPH-HCID. Samples were obtained from the river seep near SED-4/SED-5 and from wells MW-22, MW-27 and MW-39, and analyzed for physical parameters including specific gravity, viscosity, surface tension and interfacial tension. The test results are summarized below:

- Specific gravity ranges between 0.9676 (MW-27) and 0.9922 (MW-39). This indicates that the specific gravity is relatively consistent, and that the specific gravity is slightly less than water (Specific Gravity = 1). Therefore, the product will float on water.

- Viscosity at 7.5 ºC (45 ºF) ranges between 1,035 centipoise (cP) (MW-27) to 95,350 cP (MW-39). This indicates that the viscosity varies greatly. This is probably due to the different product composition of the samples. The viscosity of lighter hydrocarbons present in diesel is much lower than the heavier hydrocarbons that are present in bunker C, and the chemical analyses demonstrate that sample MW-39 contains mainly heavier hydrocarbons. The lower viscosities are more typical of the free product present throughout most of the plume area and seeping into the river.

- Surface tension ranges from 33 dynes/cm (MW-22) to 39 dynes/cm (the river seep). Surface tension describes the force required to break the surface of the liquid. The surface tensions of the product samples are relatively consistent and lower than water (72.8 dynes/cm at 20 ºC).

- Interfacial tension ranges from 25 dynes/cm (MW-39) to 81 dynes/cm (MW-27). The other two samples contained interfacial tensions of 27 and 49 dynes/cm; this indicates that the value of 81 dynes/cm may be an overestimation since this number exceeds the surface tension of water and is disproportionately higher than the other sample results. Interfacial tension is the force required to rupture the interface between two liquids (in this case, the product sample and water. This varies considerably for the different samples; it indicates that the two liquids will remain fully separate rather than mixing.

3.2.2 Location and Extent of Free Product

Several discrete areas of free product are present within the site. A site-wide fluid gauging event was conducted in January and February 2002 for the *Supplemental RI*. Figure 3-1 shows the estimated extent of free product throughout the site based on the 2002 measurements. The areas of free product are discontinuous and are present both on and off the railyard. The "apparent" thickness of the free product within the plumes has been as great as 4 feet (in well MW-36); however, it tends to have an average thickness of approximately 0.5 foot (RETEC, 2002a). Between many of these areas of free product are areas of residual product. The lateral extent and location of free product measured in the monitoring wells changes as a result of water table fluctuations in the smear zone, expanding and contracting within a relatively constant overall area of residual product. This fluctuation also affects the product thickness measured in wells as LNAPL moves slowly with respect to water table changes. Fluid levels have been gauged from selected wells on a monthly basis since the site-wide gauging event in 2002. The fluid levels have been provided to Ecology in the monthly progress reports for the site. These measurements indicate that free product is also typically present on the railyard in wells MW-8, MW-6 and 2A-W-4.

Figure 3-1 also shows areas of suspected or potential free product. No data are available to confirm whether free product is present in these areas. Extrapolations from data in other areas of the site indicate that free product may be present in these areas; however they have not been included in the areas of known free product based on area soil quality data, and groundwater quality data.

The largest two free product plumes are present in the northwest part of the site, underlying residential and commercial properties. These two plumes have migrated downgradient from the source areas on the railyard since the original releases, and extend to the northwest and towards the South Fork Skykomish River. The migration of free product in the plumes has been curtailed by the installation of the hanging barrier wall in 2001 along West River Road. The rate of migration is slow, as in evidence that the plume is still present within the site, many years after the original releases. The actual rate of migration is not known. Oil was observed seeping into the South Fork Skykomish River as early as the mid-1920s.

Downgradient from the barrier wall, the extent of free product in the levee has not been determined from examination of soils in the levee or soil sample data. However, the locations of seeps in the river bank approximately line up with the plume locations south of the barrier wall; therefore, it is assumed that the plumes extend to the river and detailed delineation of the plume under the levee is not considered necessary for this Final FS.

The extent of free product, presented on Figure 3-1, is slightly different from the extent of free product presented in the Supplemental RI. This is based on a more extensive comparison between the fluid-level measurements and the soil and groundwater data, and because fluid levels have been measured from some additional wells (most notably 5-W-5) since the Supplemental RI was completed.

The rate of free product migration is slow, and the extent of free product does not appear to have changed significantly since the Draft RI (RETEC, 1996). The plume boundaries appear to fluctuate over time. The fluctuation may be due to changes in the water table elevation; therefore only general assumptions can be made from the product thickness data. The occurrence and thickness of free product has been measured from selected wells on a monthly basis. Table 3-1 presents fluid gauging results from selected wells for 2002 through 2004. These measurements indicate that the thickness of free product in a well may fluctuate over time. Figure 3-10 presents a graph of product thicknesses in MW-36. This shows that the product thickness can vary significantly without showing discernable trends on a monthly basis. Figure 3-10 also presents a hydrograph for the same time period. Comparison of the hydrograph with the product thickness indicates that there may be a negative correlation between product thickness and fluid levels; that is, the measured product is thicker when the groundwater levels are lower. The reason for this correlation is unclear, however it suggests that free product is trapped in the soil below the groundwater surface as the groundwater level rises. This is a reasonable conclusion, since the specific gravity of the LNAPL is close to that of water and the viscosity is higher than water. With respect to product migration, the rate of change can be measured in years;

therefore, the extent of free product can be considered relatively constant for purposes of estimating cleanup requirements.

3.3 Groundwater Quality

Water has been sampled from wells throughout the site to assess the impacts of site contamination on groundwater quality. The most extensive groundwater sampling was conducted for the Supplemental RI (RETEC, 2002a); it consisted of site-wide sampling during January 2002 and January 2003. These groundwater-sampling rounds included samples from approximately 50 monitoring wells, many of which were installed for the Supplemental RI. The Supplemental RI provided the most comprehensive data on groundwater quality for the site. Groundwater samples were submitted for analysis of TPH-Dx. Selected samples were also submitted for analysis of PAHs, BTEX, and/or EPH/VPH. In addition, one sample was submitted for PCB analysis.

3.3.1 Petroleum Hydrocarbons in Groundwater

Groundwater has been contaminated with petroleum hydrocarbons. All groundwater samples have been analyzed for TPH. Groundwater samples have also been collected from selected wells for PAHs, BTEX, and/or EPH/VPH. Groundwater samples were analyzed for PAHs, BTEX and EPH/VPH to provide additional information on the composition of the petroleum hydrocarbons, to provide information for the development of cleanup levels using MTCA Method B criteria, and in accordance with MTCA (WAC 173-340-900, Table 830-1).

3.3.1.1 Total Petroleum Hydrocarbons in Groundwater

TPH in groundwater was analyzed using method NWTPH-Dx. This method reports diesel range (TPH-D, C12–C25) and motor oil range (TPH-MO, C25-C36) organics. Groundwater samples were collected site-wide during January 2002 and January 2003. The January 2002 TPH data are presented in the Supplemental RI (RETEC, 2002a). The groundwater analyses from samples collected in January 2003 were re-reported to reflect detected concentrations between the method detection limit (MDL) and the reporting limit (RL). North Creek Analytical data reports for the re-reported data are provided in Appendix E. Figure 3-11 shows the extent of TPH (measured as NWTPH-Dx) in groundwater at concentrations above the MTCA Method B cleanup level (208 µg/L – see Section 5) that was measured during January 2003 and re-reported as described above. Table 3-2 presents the TPH data for both sampling events and includes the re-reported data. The TPH-D concentrations from the two sampling events ranged from below detection limit (0.25 mg/L) to 2.6 mg/L in 2002 and 3.33 mg/L in 2003. The highest concentration was present in 2A-W-6 during both sampling events. The highest concentration appears to be in the eastern part of the site. This relates to the eastern free-product plume that contains a higher diesel-to-motor oil ratio.

The TPH-Dx concentration generally was greatest in or close to the free product plumes in nearby areas that contain high concentrations of residual product. TPH concentrations in the area generally exceed 0.5 mg/L.

3.3.1.2 Polynuclear Aromatic Hydrocarbons in Groundwater

Groundwater samples from selected wells were analyzed for PAHs in January 2002 and in August 2002. The groundwater data (Table 3-3) indicate that concentrations of most PAHs in most groundwater samples were generally below detection levels during both sampling events. Where PAHs were detected, concentrations generally decreased between the two sampling events. The data showed that PAH occurrences are closely related to areas with free product on the railyard. PAHs are not detected in samples collected within 300 feet of the South Fork Skykomish River. PAHs may sorb to soil closer to the source and are not as mobile and will not transport as quickly as other chemicals in the plume. This ‘partitioning’ is another possible reason for the difference in chemical differences across the site.

Fluorene is the most widely distributed PAH, followed by acenaphthene. The data also show a compositional difference between dissolved PAH in the groundwater in the western part of the site and the groundwater in the eastern part of the site. The dissolved hydrocarbons in the western part of the railyard contain elevated concentrations of fluorene and low concentrations of acenaphthene, whereas the dissolved hydrocarbons in the southern and eastern parts of the railyard contain several additional PAHs. The reason for the variations are not fully understood, however the variations are consistent with changes in the hydrocarbon ranges present within the site and probably result from different sources across the railyard.

3.3.1.3 Benzene, Toluene, Ethylbenzene, and Xylenes in Groundwater

BTEX are not significant contaminants associated with the Former Maintenance and Fueling Facility. Groundwater samples from 31 wells were submitted for analysis of BTEX using EPA Method 8020 during the Supplemental RI. The BTEX components were below the detection limits in all samples except for toluene (1.80 μg/L) in MW-11. This is consistent with the BTEX results presented in the Draft RI Report (RETEC, 1996) Groundwater samples were also collected during August 2002 for BTEX analysis (Table 3-4). A comparison of the data collected during the two sampling events indicates that only two groundwater samples have contained BTEX compounds and no consistent trends are evident from the data.

3.3.1.4 Extractable and Volatile Petroleum Hydrocarbons (EPH/VPH) in Groundwater

Groundwater samples collected from 20 wells have been analyzed for EPH/VPH as part of the Supplemental RI. These analysis indicate that they detected fractions are the C10 to C34 aliphatics and C12 to C34 aromatics. EPH/VPH fractions were only detected in groundwater samples from five wells. Only the groundwater sample from MW-39, a well containing free product, contained detectable EPH/VPH in several fractions. EPH/VPH was detected in 2003 but not in 2002 from this well. The discrepancy indicates that free product may have been entrained in the 2003 sample whereas no free product was entrained in the 2002 sample. Furthermore, most of the EPH/VPH results from this well and the others report hydrocarbon fractions greatly above their respective solubility limits. This implies that, where detected, EPH/VPH in groundwater results from the presence of entrained free product in the groundwater samples.

Data collected from the site show no correlation between EPH/VPH and NWTPH-Dx analyses for groundwater. Figure 3-12 provides a comparison of the groundwater data to illustrate this lack of correlation.

3.3.1.5 Metals in Groundwater

The extent of elevated metals concentrations in groundwater has been evaluated in previous studies (RETEC, 1996; RETEC, 1997). These previous studies concluded that metals are not significant site groundwater contaminants, and that the metals appear to be at background concentrations.

3.3.1.6 Polychlorinated Biphenyls in Groundwater

PCBs were not detected in any wells during the 1996 RI. Thirteen wells located in the vicinity of previous PCB detections in soil or other areas of potential concern were sampled quarterly for PCBs. In 1993, PCBs were detected in well MW-32 at a concentration of 0.11 μg/L (Aroclor 1254). Groundwater samples from MW-32 were tested for PCBs during two quarters of the RI sampling and during the Supplemental RI; PCBs were not detected.

3.3.1.7 Physical Chemistry of Groundwater

For the Supplemental RI (RETEC, 2002a), groundwater samples from selected wells were analyzed for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, turbidity and temperature. The DO data indicate that dissolved oxygen concentrations from samples from wells within areas of known contamination or hydraulically downgradient from these areas (with the exception of MW-44, located west of the barrier wall) are below the detection limit of the field measurement instrument. Dissolved oxygen concentrations in groundwater samples that are not from areas with petroleum hydrocarbon contamination ranged from 0.2 to 5.4 mg/L, which is within the range of typical concentrations of dissolved oxygen in groundwater.

The lowest ORP values are generally present in wells in the vicinity of the railyard. Low ORP values can indicate anaerobic or anoxic conditions often seen in contaminated groundwater. Higher values are present in the wells in the western portion of the site, with the highest value in MW-44.

The pH, turbidity, conductivity, and temperature of groundwater were measured in the field during the Supplemental RI. A summary of the results is provided below.

- pH was 5.02 to 6.47 standard units
- Turbidity was 1.7 and 20.5 Nephelometric Turbidity Units
- Conductivity was 37 to 268 micromhos per centimeter (µmhos/cm)
- Temperature ranged from 2.8 to 8.6 ºC.

Additional details are provided in the Supplemental RI (RETEC, 2002a).

3.4 Sediment Quality

There are two separate areas of sediment affected by contaminants at the site, as described in Section 2.2.1. The first is along the south bank of the South Fork Skykomish River and the second is along the former Maloney Creek channel. The sediment quality in these two areas is summarized below.

3.4.1 South Fork Skykomish River Sediment

Sediment has been impacted by free product seeps and dissolved groundwater fractions entering along South Fork Skykomish River. The free product has resulted in high TPH concentrations (maximum TPH of 87,000 mg/kg) at the identified seep locations. The TPH concentrations decrease rapidly away from the actual seep locations and data indicates that impacts extend no more than ten feet into the river, and often considerably less.

Sediment along the bank of the South Fork Skykomish River has been sampled for the RI and the Supplemental RI (RETEC, 1996; RETEC 2002a). In addition, sediment samples were collected during 2002 for additional sediment bioassays; these samples were analyzed for TPH, EPH/VPH, BTEX, and PAHs. Additional sediment sampling was conducted during 2003 to establish cleanup levels for groundwater that protect aquatic organisms in sediment (RETEC, 2003). Figure 3-13 shows the extent of TPH in the sediment along the bank of the South Fork Skykomish River. The results from this testing and a more complete discussion of the sediment sampling are presented in Appendix A.

3.4.2 Former Maloney Creek Sediment

The former Maloney Creek channel and in adjacent areas were investigated as part of the Supplemental RI. Figure 3-11 presents a longitudinal transect from sample 3-SD-1 downstream of the culvert to 2B-SD-6 immediately downstream of the upper road culvert and five transverse transects. The profiles show that the fine-grained sediment is limited in vertical extent, and that although TPH is present within the shallow sediment, higher concentrations are present in the underlying sand and gravel. The contamination data is summarized on Figure 3-14 in two ways: (a) impacted (visual, odor, sheens, or product) soil noted during the drilling is indicated by cross-hatching, and (b) TPH-T (diesel and lube oil range) values from collected samples in the intervals indicated next to the boring.

The transects indicate that the following distinct segments can be identified in the former Maloney Creek channel, based on differences in topography and lithology. These areas are described in Section 2.2.2 and are summarized below.

1) An upstream segment with a steep gradient in which the channel is narrower and channelized between steeper banks, and essentially is a drainage ditch for the Old Cascade Highway and surrounding residential areas. This section contains silty sand (possibly older fill material) in the surface layers. The sample 2B-SD-6 is located at the point were the drainage ditch widens into a marshy swale.

2) A middle segment encompassing samples 2B-SD-5, 2B-SD-4 and 2B-SD-3. This area has a gentle gradient and wider profile and one to three feet of silty sediment typically overlays the alluvial sands and gravels typical of the area. This area is wooded and marshy, with slower water flow and presence of side channels and marshy swales. The section narrows just south of 2B-SD-5 by a private residence and adjacent yard. A pool area is present on the western end of this segment containing samples 2B-SD-2 and 2B-SD-1. At 2B-SD2 gravelly alluvial material reaches the surface and may represent an old riffle area with steeper slope. Downstream of 2B-SD-2 a deeper scour or plunge pool is present behind the road culvert. The plunge pool is filled with a foot of silt overlying 5 feet of silty sand. The pool area is marshy and open, lacking tree growth.

3) A segment downstream of the 5th Avenue/Old Cascade Highway culvert. This portion is a steeper, scoured channel, with limited accumulation of fines. This area has the characteristics of a creek. Sample 3-SD-1 was collected here.

Groundwater gauging data indicate that groundwater levels are located well below the bed of the channel during seasonal low groundwater levels. During measured seasonal highs the groundwater typically rises to within a foot of the channel, and at times groundwater may surface in the former creek bed. This is significant because it indicates that hydrocarbons that are typically contained in the sand and gravel that underlies the former channel may in some areas also affect the shallow sediment contained within the channel (i.e. the sediment is within the groundwater smear zone).

Low concentrations of TPH, up to 48 mg/kg, were detected in sediment from the upper segment.

The middle segment of the former Maloney Creek channel is underlain by contaminated sand and gravel in the smear zone below the surface sediment. This contamination in the smear zone is continuous with the affected property, and is similar in concentration, type, and hydrogeological characteristics to that found in the surrounding soils. In general, contamination is greater in the sand and gravel beneath the surface sediment and does not appear to be significantly impacting the sediment near the ground surface. This is illustrated on Figure 2-5, where it can be noted that visibly impacted subsurface soil is generally confined to the deeper gravel layers, as is the situation in the adjacent railyard. Near-surface concentrations of TPH are notably lower than in the visibly impacted deeper layers. This suggests that there appears to be no upwards transport component of contaminants in most of the former Maloney Creek channel.

However, in the area around 2B-SD-5, substantial contamination is present close to the ground surface, particularly immediately adjacent to the private residence at location 2B-B-4. This is the only area where the subsurface smear zone extends into the silty depositional material. This contamination could be due to smearing of underlying contamination in groundwater or possibly from historic drainage into the channel through an oil drain immediately upstream of 2B-SD-5 (Figure 2-2).

The lower segment (pool area) upstream of the culvert contains moderate contamination (500 mg/kg TPH) in the depositional surface layers. This area functions as a sink for contaminated sediment from upstream, as evidenced by the deep layer of sedimentary material at this location. Deeper sediment shows declining concentrations, indicating that older, historical releases, if any, are not resulting in significant deleterious impacts. No high concentrations of TPH indicative of residual contamination remaining from the time when active discharge occurred to the channel are present.

The channel section downstream of the culvert contains some contamination with TPH immediately downstream of the culvert, however the lower section is generally scoured free of fine-grained sediment, and therefore contamination is unlikely to accumulate in this area for extended periods of time.

The hydrocarbon composition provided by EPH/VPH data (RETEC, 2002a) indicates that the TPH is similar to that found elsewhere throughout the site, with heavier aliphatics and aromatics typical of diesel and motor oil range hydrocarbons (TPH-MO) predominant. PAHs were detected in the smear zone of the former channel, where TPH concentrations are highest; however, PAHs are generally absent from the surface sediment and underlying sediment (0 to 2.5 feet). Note that although surface sediment is defined as the top 10 centimeters, sample collection consisted of a composite of the top 2.5 feet, and is here used as an estimate for the surface sediment. BTEX is absent from the sediment, which is consistent with the soil and groundwater quality in this area. Metals (arsenic and lead) were consistent with background concentrations. PCBs were not detected within the sediment at quantitation levels generally in the 0.1 mg/kg range or less (RETEC, 2002a).

3.5 Surface Water Quality

Groundwater from the site recharges the two surface water bodies in the study area: the South Fork of the Skykomish River and, more occasionally, the former Maloney Creek channel. Free product seeps migrate slowly into the river throughout much of the year, and groundwater with dissolved petroleum hydrocarbons flows into the river. The river level seasonally varies with flow. There are generally two high and low flow periods each year. One of the periods of high flow generally occurs in November through early March, the other high flow period occurs between May and July during runoff from snowmelt.

Seeps have not been observed during high flow conditions. This is probably largely because the seepage face is submerged under several feet of fast flowing river water. The seeps are also likely to be less during times of high water because the hydrostatic pressure from the higher river water would form resistance to seepage, and the water would also lower the temperature of the product and increase the viscosity, resulting in more limited product mobility.

During low water conditions, the riverbank is typically dry and there are either pools of water close to the bank or low flowing water. The seeps are more noticeable during these times and product seeps may lead to sheens on the water close to the bank, or accumulate in pools of low/no flowing water. Booms have been placed and maintained along the riverbank as an interim cleanup action, to contain the product close to the actual seep locations. Absorbent pads and pom-pom booms are used to clean up seeped petroleum. Surface water samples were collected from seven locations in the South Fork Skykomish River, Maloney Creek and the former Maloney Creek channel on four occasions during the RI (RETEC, 1996). Historical correspondence dated from 1926 to 1931 suggests that free product releases to the South Fork Skykomish River may have been more extensive in the past. Product was reported in these correspondences to have been observed in 1930 at one location a few miles downgradient from the Site. Recent surface water samples show that there are generally no impacts to surface water in the South Fork Skykomish River, Maloney Creek, or the former Maloney Creek channel (Table 11-15, RI Report, RETEC, 1996).

Surface water temperature, pH, DO and conductivity were collected as part of the RI sampling (RETEC, 1996). These data indicate that the water in both the South Fork of the Skykomish River and the former Maloney Creek channel is neutral to basic (6.6 to more than 10 standard units [su]), has relatively low conductivity (22 to 338 µmhos/cm), and is well oxygenated (greater than 9 mg/L DO). No significant differences were noted between the river readings and those from the creek.

3.6 Air Quality

Air monitoring was conducted during drilling and excavations for the RI and Supplemental RI (RETEC, 1996: RETEC 2002a). This monitoring indicated that vapors from petroleum hydrocarbons have not adversely impacted air quality. This data demonstrates that there is no significant potential for migration of volatile compounds to the air from impacted soil and groundwater. During health and safety monitoring for the Supplemental RI, readings of total volatile organics taken during sampling were consistently non-detect in the breathing zone, with the exception of one reading of 0.5 parts per million (ppm) during sediment sampling. Volatile organics were only detected at appreciable levels during hollow-stem auger drilling of boring B-10, and from the top of the casing during air rotary drilling of boring B-7.

In most cases, detected values correspond to wells with measurable free product accumulations. Only four compounds have estimated air concentrations that total greater than 0.00001 mg/kg, including mercury, 2-methylnaphthalene, butyl benzyl phthalate, and xylenes.

Indoor air sampling was performed under the 1993 Agreed Order with Ecology in six buildings between 1997 and 1999. Samples were analyzed for an extensive suite of VOCs by EPA Method IP-1A and SVOCs by EPA Method IP-7. Indoor air was sampled in response to requests by Skykomish residents. The Washington State Department of Health (WDOH) in its "Health Consultation" dated August 30, 1999 concluded that 'exposure to contaminants detected in indoor air over the seven sampling events are not at concentrations expected to pose a health threat' and that 'there were no apparent public health hazard from exposure to contaminants detected in any of the locations' and communicated this conclusion to the public by issuing an "Environmental Health Update" in June 1999 (WDOH, 1999) and presenting their findings at a public meeting in Skykomish.

3.7 Summary of the Nature and Extent of Contamination

The following summarize the conclusions of the nature and extent of contamination:

- The most common contaminant at the site is petroleum hydrocarbons. These have been measured as TPH, PAH, BTEX and EPH/VPH in compliance with WAC 173-340-900, Table 830-1.

- It is estimated that several plumes of free petroleum product are present at the site. These plumes are present on the railyard, in residential and commercial areas, and along the riverbank as free product seeps through portions of the riverbank west of the Skykomish River Bridge.

- The highest concentrations of petroleum hydrocarbons in soil, groundwater and sediment are typically present in the same location as free product.

- Petroleum hydrocarbons are present in the surface and vadose zone in historical source areas on the railyard and limited areas off the railyard. These areas may contain high TPH concentrations in the surface zone and vadose zone soil, but do not always coincide with the highest concentrations of TPH in smear zone soil.

- TPH is more widespread in the smear zone, and is typically found in both the soil and groundwater. This distribution is due to migration of petroleum hydrocarbons as free product with groundwater downgradient from the original source areas.

- Free product has migrated to the South Fork Skykomish River and is seeping through the banks into the river. The impacts to sediment in the South Fork Skykomish River appear to be restricted primarily to those seep locations.

- Shallow sediment in the former Maloney Creek channel, adjacent to the railyard, has been impacted. The shallow sediment in the creek is underlain by sand and gravel with high TPH concentrations similar to the condition observed in surrounding smear zone soils. The sediment contamination may result from smearing from the underlying soil at times of high groundwater levels.

- Elevated concentrations of lead and arsenic are present in some soil on the railyard. These concentrations are restricted to the surface zone soil.

- Lead and arsenic are not elevated in groundwater.

- There are some isolated areas with lead in surface soil in the residential/commercial area north of the railyard. The source(s) of this lead are unknown.

- PCBs have been detected in surface soil from portions of the railyard. The PCBs are generally present in the vicinity of the former substation and old transformer pads.

- PCBs have not been detected in smear zone soil or in groundwater anywhere throughout the site.

This Final FS summarizes the nature and extent of contaminants based on data collected to date for the RI (RETEC, 1996), Supplemental RI (RETEC, 1999) and other referenced investigations. Some public comments expressed concern that certain areas that should have been sampled were not sampled, and that the lack of data from these areas constituents data gaps. These areas include the Former Channel of Maloney Creek, the area south of the Former Channel of Maloney Creek and the flood control levee on the South Fork Skykomish River.

The main comments concerning the Former Channel of Maloney Creek are that the channel may have followed a difference course and that there may have been other low-lying areas into which contaminants could have migrated while releases were occurring, and that the former channel bed itself has not been sampled. In addition, there were comments that samples collected from the current channel bed were too shallow. BNSF does not believe additional sampling is necessary in this area because historical records such as the 1926 Sanborn map indicate that the course of the former Maloney Creek channel is unchanged since the mid-1920s and that no additional low-lying areas were connected to the former channel of Maloney Creek.

The comments regarding the area south of the Former Channel of Maloney Creek request that additional soil samples are collected south of the Old Cascade Highway to place a southern boundary around the contamination adjacent to the former Channel of Maloney Creek. BNSF does not believe that additional sampling is needed in this area because this area is upgradient of the historic source areas, and there were no formerly existing transport pathways to transport contamination to these areas.

The comments relating to the levee state that the nature and extent of contamination under the levee is unknown. BNSF does not believe additional sampling is needed in this area because the seeps into the South Fork Skykomish River appear to be downgradient of the free product plumes upgradient of the barrier wall. The extent of free product in the levee is closely related to the upgradient plume locations and it is unnecessary to advance boreholes through the levee at this time to confirm the conclusion that free product is present under the levee.

Ecology has collected additional soil and groundwater samples from areas mentioned in the public comments. These data have been used, as applicable, to revise the maps depicting the nature and extent of contamination. The investigation logs and data are presented in Appendix F. BNSF completed extensive, additional sampling during the Supplemental RI in response to public comments and comments form Ecology.

3.8 Indicator Hazardous Substances

This section identifies indicator hazardous substances for purposes of defining site cleanup requirements. Indicator hazardous substances are the compounds found at the site that are most prevalent and comprise the greatest risk to human health and the environment at the site. Also, by focusing site cleanup on these compounds, the majority of the risk at the site is eliminated.

MTCA allows for the elimination "from consideration those hazardous substances that contribute a small percentage of the overall threat to human health and the environment. The remaining hazardous substances, or indicator hazardous substances (IHSs) can be implemented at sites that are contaminated with a large number of hazardous substances" for monitoring during "any phase of remedial action for the purpose of characterizing the site or establishing cleanup requirements for the site" (WAC 173-340-703). The use of IHSs in development of a final remedy for this site is appropriate, because from the large number of chemicals, only a few have been detected commonly and only a few contribute to a significant overall threat. The RI and Supplemental RI (RETEC, 1996; RETEC, 2002a) were designed to investigate the presence and distribution of all hazardous substances at the site.

The data collected for the RI and Supplemental RI was rigorously screened to develop the list of IHSs for the Skykomish site. Note that TPH is considered an IHS for all media, and was not subjected to the screening process. Details of the analysis are presented in Appendix G. This information is summarized below by medium and in Table 3-5:

- In addition to TPH, soil at the site has eight IHSs: arsenic, lead, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo-(k)fluoranthene, chrysene and indeno(1,2,3-cd)pyrene.

- In addition to TPH, the sediment has the following four IHSs: lead, benzo(a)anthracene, benzo(b)fluoranthene and chrysene.

- The groundwater IHSs consist of TPH, benzo(a)anthracene, chrysene and fluoranthene.

- Surface water does not contain any IHSs as such, other than TPH; however, since groundwater discharges to surface water and groundwater must be protective of surface water, the IHSs for groundwater will also apply to surface water for purposes of developing cleanup levels in Section 5.

The distribution and movement of IHSs is summarized in Section 4, as part of the Conceptual Site Model.

4 Conceptual Site Model

Data collected during the RI, Supplemental RI and interim actions provide all the information necessary to understand the nature and extent of contamination and potential exposure to human health and the environment at Skykomish. This section of the Final FS synthesizes the available data into a conceptual model of contaminant occurrence, movement, and potential exposure. The conceptual site model presented herein is primarily qualitative in nature and serves to translate available physical, chemical, and biological data into an accurate narrative and graphical representation of site conditions. The model serves as a useful aid to the development of cleanup standards and cleanup action alternatives that are the subject of Sections 5 though 10 of this Final FS.

4.1 Source Characterization

There are no active, operating sources of hazardous substances at the Site. Past releases from storage facilities and from former fueling and maintenance activities at the facility are the presumed original primary sources of contaminants. Three distinct areas can be defined on the basis of historical structures and known operations. These areas are the maintenance area, fueling area, and the substation and sandblasting area. Railcar and locomotive maintenance activities were conducted at the engine house, turntable, machine and boiler shop, and areas immediately east of these structures. Fueling operations were performed at the fueling stations, concrete oil unloader pits and oil pump house. Finally, transformer pads near the east substation were used to store electrical transformers, and in the 1960s the substation was used as a sandblasting facility.

There are no continuing primary sources of hazardous substance releases at the site. All existing contamination derives from historical releases that occurred during operation of the Former Fueling and Maintenance Facility (from 1893 to 1974). Historical releases (e.g. spills, leaks, discharges) from storage facilities and former fueling and maintenance activities are the presumed primary sources of contaminant release. A search of historical records revealed no documentation of fuel or other contaminant releases.

Figure 2-2 shows three generally contiguous primary source areas (Maintenance, Fueling, and Electrical Substation/Sandblasting), defined on the basis of historical records of structures and known operations. The three areas are all located east of 5th Street between the existing rail lines and the former Maloney Creek channel.

Potential secondary sources of contamination are areas currently containing free product in the smear zone and vadose zone soil.

4.2 Indicator Hazardous Substances and Impacted Media

The conceptual site model focuses on contamination of soil, groundwater, surface water and sediment arising from releases of metals (primarily arsenic and lead), petroleum fuels and PCBs (Table 4-1). The analysis of all hazardous constituents detected at the site (see Section 3.3) demonstrates that risks to human health and the environment are dominated by these contaminants.

In Section 5, cleanup levels are ultimately established for metals, petroleum hydrocarbons, select PAHs and the more updated IHSs detected at the site (e.g., PCBs). However, near-surface metal deposits within the railyard and the magnitude and impact of petroleum fuel releases, are the central driving force behind the development and evaluation of cleanup action alternatives presented in this Final FS.

With the exception of near-surface soil, the IHSs at the site are TPH and the PAH associated with the TPH residues. The TPH is relatively free of volatile contaminants (BTEX) that are common to lighter fuels (e.g., gasoline). Surface soil (0 to 2 feet bgs) is considered separately from deeper soil in this analysis because metals are found predominantly only in surface soils.

The following sections demonstrate how the IHSs listed in Table 4-1 have or have not migrated from their source.

4.2.1 Metals

The nature and extent of metals contamination at the site were described extensively in Section 3.1.1. Lead and arsenic are the only metals IHSs at the site. Moreover, soil is the only medium that contains metals above background and IHS screening levels. The distribution of metals is largely confined to the railyard where potential sources resulted from railyard operations such as coal-burning locomotives, sandblasting, use of lead-containing fuels, painting and other metal-producing activities. Consistent with these near-surface source activities, metal impacts are confined to surface and near-surface (less than 5 feet bgs) soil. Further, there are no observable groundwater impacts from these near-surface metal deposits. This suggests that dissolution of metals into surface water and infiltration of surface water to groundwater is not detrimental to groundwater quality.

Soil sampled off the railyard contained occasional and sporadic detections of lead and arsenic above background. The source(s) of this lead and arsenic is unknown.

4.2.2 Petroleum Hydrocarbons

The nature and extent of petroleum hydrocarbons at the site is described extensively in Section 3. The source(s) of these contaminants were releases of petroleum fuels during operation of the former fueling and maintenance facilities. While these sources no longer exist, the resulting impacts to soil and groundwater quality require an assessment of exposure risks (Section 4-4) and development of cleanup standards (Section 5).

A continuing impact of the historical petroleum releases on soil and groundwater quality results from the presence of free and residual product in the subsurface. Free product (oil) discharges to the river are observed at a number of seep locations opposite the levee and west of 5th Street. The residual product (i.e., that which does not appear as a distinct separate layer or move as a separate phase under the influence of gravity and groundwater flow conditions) serves as a secondary source of petroleum hydrocarbons that dissolve in groundwater, which ultimately discharges to the river. Therefore, knowledge of the characteristics and behavior of free and residual product and its interaction with groundwater and soil is important to understanding current site conditions.

4.2.2.1 Characteristics and Behavior of Free and Residual Product

LNAPLs or “light nonaqueous phase liquids” can describe both free (mobile) and residual product. MTCA defines LNAPL as a “hazardous substance that is present in the soil, bedrock, groundwater or surface water as a liquid not dissolved in water.” LNAPLs derived from petroleum fuels are complex mixtures of organic (carbon-based) molecules with slight solubility in water. The term “light” refers to the density of petroleum liquids as typically being less than that of water. The term “nonaqueous” refers to the fact that petroleum liquids are not miscible with water (i.e., they do not mix with and fully dissolve in water to form a single phase). Instead, LNAPL exists as a separate phase in contact with water and soil particles. LNAPL at the Skykomish site is derived from releases of petroleum fuels (primarily diesel and bunker C fuel oil) used at the Former Fueling and Maintenance Facility.

The general character and behavior of free and residual product in the subsurface environment is illustrated on Figure 4-1. MTCA defines “free product” as LNAPL “present in the soil, bedrock, groundwater or surface water as a distinct separate layer” and “capable of migrating independent of the direction of flow of groundwater or surface water.” Figure 4-1 graphically depicts contaminated and uncontaminated soil conditions. LNAPL that reaches the water table remains near the groundwater table because the density of the LNAPL is less than that of water. Once at the water table, LNAPL becomes “free product.” As the water table fluctuates seasonally, related to river level changes and precipitation events, the free product rises and falls with the groundwater level and "smears" the soil within the fluctuation interval. The "smear zone" is generally defined by the seasonal low water level at the base, and the seasonal peak high water level at the top. The buoyancy of product in water inhibits LNAPL migration below the seasonal low water table.

Petroleum hydrocarbons and water share soil pore space (Figure 4-1). This sharing limits product mobility and complicates its recovery from the subsurface. Released product migrates downward through the vadose zone under the influence of gravity. Above the groundwater table, volatile product components, where present, separate into soil gas and form vapor plumes local to the release. This is not a significant concern at the Skykomish site based on empirical data obtained from indoor air sampling during seven sampling events at six residences and structures throughout town (refer to Section 5.2.1.4 for additional discussion). Upon reaching groundwater, the product spreads laterally and begins to dissolve into groundwater, thereby forming the dissolved-phase plume (Figure 4-1(5)). Typically, dissolved-phase plumes attenuate via biological processes over short distances (e.g., a few hundred feet) (Wiedemeier et al., 1999). Over extended periods of time, the product is degraded and the most soluble compounds weather out of the product, leaving behind a mixture of low-solubility compounds that collectively have a relatively high viscosity. The viscosity of product samples taken from the site is very high (Table 4-2) compared with values typical of diesel and bunker C fuel oil; this is one indication that the product at the Site is highly degraded.

The soil medium within which LNAPL exists is physically described as a porous medium consisting of solids (e.g., soil grains) and void space (soil pores). The void spaces in soil contain water (Figure 4-1(1)). Above the water table (vadose zone) air coexists with water in the pore space. Water is preferentially attracted to the solid surfaces, forms a continuous wetting phase about the soil grains, and fills the smaller pore spaces. Thus, water occupies the margins of the pore space, leaving the remaining central portions filled with air (a non-wetting fluid).

LNAPL flows downward through the vadose zone as a non-wetting phase that partially displaces air between soil particles (Figure 4-1(3)). Water remains on the particles as a continuous wetting phase. If the LNAPL is of sufficient volume (as was the case at the Skykomish site until the mid-1970s), then the LNAPL will eventually reach the groundwater table. Here, the LNAPL displaces water from the interior regions of the soil void or pore space (Figure 4-1(4)) and becomes "free product." Selective entry of free product into larger pores reflects the fact that it is physically easier for free product to displace water from large pores than smaller pores.

Initially, free product occurs in the smear zone as a continuous network of interconnected pores that contain product (Figure 4-1(4)). The product is surrounded by water that forms a continuous liquid phase about the solids. Product does not float above groundwater as suggested by the analogy of oil floating on water in a tank. Instead, product is largely submerged and its movement is constrained by the pressures needed to displace water from the pores at the margins. Product can move when it has sufficient volume to overcome these pressures.

Water and LNAPL coexist in the pores under different pressures. The difference in pressure between the product (non-wetting phase) and water (wetting phase) is defined as capillary pressure. Capillary pressure is a result of the two liquids (water and product) having different densities. This property governs the distribution and potential mobility of product in groundwater. The greater the pressure in the non-wetting phase (e.g., LNAPL), the more fully the pore space is filled (saturated) by the non-wetting phase.

The fraction of pore space occupied by LNAPL decreases over time as the volume of LNAPL is depleted. Depletion occurs from the volumetric movement of free product in the direction of groundwater flow and attenuation processes such as dissolution. With depletion, free product flow paths become smaller and more tortuous. This reduces the ease with which free product can move (mobility). Ultimately, the free product then breaks into isolated blobs and ganglia that are discontinuous and immobile as a separate residual liquid phase (Figure 4-1(6)).

Residual product is present wherever LNAPL has come into contact with soil. Thus, source areas where releases occurred and areas in the path of LNAPL migration contain residual product. Residual product is “trapped” in the soil pores by capillary pressures and will not flow under the influence of gravity or groundwater flow.

Residual product is immobile and not “free product” but may remain a source of dissolved contaminants in groundwater. In the smear zone (the depth zone through which fluid levels fluctuate), soluble fractions of petroleum are dissolved and mobilized from the residual product until an insoluble residue remains. This is different than residual product left in the vadose zone (the unsaturated zone above the smear zone) that will not move under the force of gravity. Residual product in the vadose zone is also subject to dissolution, but because the smear zone is below the groundwater table some of the time, the rate of dissolution is likely to be greater within the smear zone.

MTCA (WAC 173-340-747(10)(b) defines residual saturation as the “concentration of hazardous substances in the soil at equilibrium conditions. At conditions above the residual saturation, the NAPL will continue to migrate through the soil due to gravimetric and capillary forces and may eventually reach the groundwater, provided a sufficient volume of NAPL is released." This definition implies that the term residual saturation refers to the vadose zone only. This residual saturation concentration depends on the physical properties of the product and the soil. Following dispute resolution, Ecology has imposed the following standard for residual saturation of TPH in soils – 2,000 mg/kg. BNSF respectfully disagrees with this decision and reserves the right to seek review of Ecology's decision to the full extent provided under by law.

4.2.2.2 Influence of the Barrier Wall on Free Product

The barrier wall constructed parallel to the South Fork Skykomish River in August 2001 was part of an interim action to block free product from entering the river. The barrier wall extends from near the ground surface (above the water table) to below the seasonal groundwater table. The free product, which tends to move with groundwater, is thereby prevented from moving further downgradient towards the river and is collected in recovery wells. Seeps observed since the barrier wall construction are attributable to free product that existed under the levee between the barrier wall alignment and the river.

The barrier wall was constructed to allow groundwater to flow around and beneath the wall, but prevent downgradient movement of free product. In the absence of product removal, mobile free product is expected to accumulate behind the barrier wall.

Groundwater generally flows in a northwesterly direction along most of the barrier wall. Groundwater elevation and flow direction near the wall have been largely unaffected by the barrier wall. Therefore, mobile free-phase LNAPL should continue to migrate toward the wall and recovery wells.

4.2.2.3 Dissolved Petroleum Hydrocarbons Groundwater

Both residual and free product are sources of groundwater contamination at the site. Individual chemical constituents of product dissolve into the passing groundwater in accordance with chemical and physical properties of the product and soil at this site. In the absence of natural degradation, these properties control the distribution of TPH constituents dissolved in groundwater. Once released into groundwater, the dissolved TPH constituents are subject to natural attenuation, such as resorption to soil particles, volatilization, dispersion, dissolution and biodegradation.

The data show that dissolved-phase TPH in groundwater is distributed in a manner that is very similar to TPH in soil. The data also show that dissolved contaminants in groundwater attenuate rapidly with distance from free product and residual LNAPL in soil. This is consistent with the generally accepted understanding of petroleum LNAPL dissolution and attenuation as reported in the literature.

4.3 Conceptual Model Summary

Figure 4-2 provides a physical conceptualization of impacts to the site. The figure summarizes and integrates existing knowledge of site geology, hydrogeology and contaminant distribution as previously discussed in this and previous sections of the Final FS. The figure is a cross section of the town from the Old Cascade Highway south of the railyard to the river north of the railyard. The geology is generalized based on information from boring logs. The seasonal high and low groundwater table defines the region labeled as the "smear zone."

Petroleum releases in former maintenance and fueling areas at the site deposited fuel (LNAPL) on the ground surface. The LNAPL migrated vertically downward into the subsurface under the influence of gravity. While a portion of the LNAPL accumulated within soil pores above the groundwater table (vadose zone) and ceased moving (residual), the releases were of sufficient volume to migrate to the water table where the LNAPL forms a discrete layer and becomes free product. Further vertical movement of product through the water table was precluded by the density differential between water and the product. Consequently, the free product spread in the upper horizon of the water table both laterally and in the direction of groundwater flow. Over time and under the influence of the prevailing hydraulic gradient, free product migrated in a north to northwesterly direction beyond the railyard boundary to the South Fork Skykomish River where seeps of free product are currently observed. These seeps resulted in sediment impacts near the south embankment of the South Fork Skykomish River where groundwater recharges the river.

Residual hydrocarbon contamination in the vadose zone is restricted to the railyard where petroleum fuel was originally released and migrated from the surface vertically to the groundwater table. Free product is mainly found downgradient of the railyard within the smear zone, where it has migrated towards the river under the influence of groundwater flow. Groundwater in contact with free and residual product in soil becomes contaminated by dissolution of hydrocarbon constituents into the dissolved phase. The plume of dissolved-phase hydrocarbon contamination migrates downgradient, eventually entering the river and impacting surface water and sediment quality. Data indicate that the dissolved hydrocarbon plume attenuates rapidly with increasing distance from areas of free and residual product in soil and that removing free product from the soil and groundwater will protect surface water. Subsurface soils underlying the former Maloney Creek channel are composed of sand and gravel, generally overlain by a thin layer of silt. The former Maloney Creek channel area consists of a deeper smear zone continually hydrologically connected to surrounding soils to the north and south of the wetland, and a shallower zone with intermittent hydrologic contact with the surrounding soil. The deeper sand and gravel is contaminated with high concentrations of TPH, however, the biologically active portion of sediments within the wetland (upper 10 cm) is largely unaffected except during very high groundwater conditions. These sporadic, high groundwater events may introduce contaminants from underlying smear zone soil into shallow wetland sediment, but if this does occur it appears to result in concentrations of less than 500 mg/kg in the biologically active zone.

Downstream bedload transport of sediment occurs during periods of heavy surface runoff. At these times, contaminated sediment may be mobilized and trapped upstream of the culvert. This is the likely source of the contamination noted in the surface sediment in this area. Sediment trapped here has filled in an old plunge pool. The decreasing concentrations at depth in older, deeper sediment suggest that the hydrocarbon contamination degrades or dissociates from the sediments over time. Discharges from the period of railyard operations when oily contamination was evident in the channel are no longer observed in the former Maloney Creek channel or its associated wetlands.

4.4 Exposure Assessment

This section identifies potential human and ecological exposures to contaminated media at the site. Consistent with WAC 173-340-350(1), this section identifies exposure scenarios that will assist in the selection of a cleanup action. Cleanup actions developed in this Final FS must "protect human health and the environment (including, as appropriate, aquatic and terrestrial ecological receptors)" (WAC 173-340-350(8)(c)(i)(A)). In order to evaluate cleanup actions, the cleanup standards must be determined. As outlined in WAC 173-340-700(5), in order to set the cleanup standards applicable to cleanup actions, the following issues must be determined:

- Nature of the contamination
- Potentially contaminated media
- Current and potential land and resource uses
- Current and potential receptors
- Current and potential pathways of exposure.

The nature of contamination and impacted media were described previously in Section 3. This section describes current and potential receptors and pathways of exposure, based on current and potential land and resource uses. Figure 4-3 is a conceptual site model illustrating potential exposure pathways present at the site.

4.4.1 Current and Potential Land and Resource Uses

Cleanup levels must derive from reasonable maximum exposures, defined as the "highest exposure that is reasonably expected to occur at a site under current and potential future site use" (WAC 173-340-708(3)(b)). This section identifies the current and future potential uses of resources where contaminated media are known or suspected to be present. The resources under consideration here are land, groundwater, surface water and sediment. The land resource may be divided into railyard and off-railyard areas.

4.4.1.1 Railyard

Most of the railyard property is currently zoned "Industrial" by the Town of Skykomish. The depot area (south of Railroad Avenue, between 3rd and 5th Street) is zoned "Public" and is within the locally-designated "Historic Commercial" area. This zoning designation is in accordance with land use planning under chapter 36.70A of the RCW (Growth Management Act). The railyard is currently used as industrial property by BNSF, and the most likely future use of the property is industrial. Trespassing is prohibited on the railyard and the general public is only permitted to cross the yard using the public right-of-way (5th Avenue). The depot building and property is currently not open to the general public. If it is opened in the future to the general public, such as for historic preservation purposes, potential exposures would be comparable to a commercial property. In response to the community's request, BNSF installed a fence along the former Maloney Creek to reduce trespassing from the residential areas south of the yard. The BNSF railyard property is "industrial property" for purposes of GMA and MTCA (RCW 70.105D.030(2)(f) and WAC 173-340-200).

4.4.1.2 Off-Railyard – Developed Property

The current land uses of impacted off-railyard properties are residential, commercial (restaurants, hotels, stores), municipal (town offices and garages), and educational (Skykomish School). Some of the properties (notably the town garages) may meet the requirements for designation as industrial property. However, for the purposes of this exposure assessment, the highest beneficial use of the developed properties off of the railyard is assumed to be residential. In addition to human health, ecological receptors must be protected as part of cleanup actions.

4.4.1.3 Off-Railyard – Undeveloped Property

Undeveloped property exists to the south of the railyard along sections of the former Maloney Creek channel and along the south bank of the South Fork Skykomish River. These areas of undeveloped property are generally wooded. The narrow strip along the South Fork Skykomish River serves as part of the King County Department of Natural Resources flood-control dike for the South Fork Skykomish River. Future development in this area is unlikely.

A portion of the former Maloney Creek channel and surrounding wooded areas exist off railyard property. There are no known development plans for this area, and due to the proximity of this land to the railyard and other residences, no development is foreseen. However, the highest potential land use for these areas remains residential.

As these areas currently are vegetated with non-cultivated plants, and may support animal life, they are potential habitat for ecological receptors as discussed in Section 2.

4.4.1.4 Groundwater

Groundwater contaminated with TPH and PAHs exists under the railyard and both developed and undeveloped off-railyard properties. Generally, the highest beneficial use of groundwater is as a source of drinking water (WAC 173-340-720(1)(a)). However, shallow groundwater in the impacted area of the Skykomish site is not a current source of potable water in Skykomish, nor will it likely be used as a source of potable water in the future.

WAC 173-340-720(2) sets forth criteria for determining whether the highest beneficial use of groundwater is potable water. Of these criteria, two are met at this site.

- ***The groundwater does not serve as a current source of drinking water* – WAC 173-340-720(2)(a)*.***

  Shallow groundwater is not currently used as a source of potable water in Skykomish. The public water supply wells for the Town of Skykomish are located approximately 0.5 mile upgradient of historic site operations and are screened about 200 feet bgs in fractured rock, presumably at the surface of the bedrock layer underlying the uppermost alluvial aquifer.

- ***The department determines it is unlikely that hazardous substances will be transported from the contaminated groundwater to groundwater that is a current or potential future source of drinking water at concentrations that exceed groundwater quality criteria* WAC 173-340-720(2)(c), WAC 173-200).**

  As stated above, current drinking water wells for Skykomish are located upgradient of the impacted groundwater plume. Based on gauging performed over at least 10 years, groundwater flow in the upper aquifer underlying the site is consistently toward the South Fork Skykomish River. Locally reversed gradients along the shoreline were observed during two pre-RI gauging events (October 1990 and December 1991). This is most likely due to transient increases in water levels in the river; the reversed gradient extended only slightly into the residential area near the river – approximately 100 to 150 feet. Further, based upon our knowledge of groundwater flow in river basins, it is correct to assume that groundwater flows toward the river.

In addition, the drinking water wells are screened to approximately 200 feet bgs. Five deep (35 to 40 feet bgs) monitoring wells have been installed at the site; none of these have ever had detectable levels of TPH. Well DW-5, located near the recovery system and screened below the LNAPL layer, has been sampled 10 times between 1993 and 1997; TPH has never been detected. Based on this data, the plume of dissolved TPH attenuates within a short distance (less than 25 feet) below the LNAPL plume. Therefore, because the drinking water wells are located upgradient of site impacts and are screened much deeper than any known groundwater contamination beneath or downgradient of the site, it is impossible that hazardous substances in groundwater underlying the site would be transported to the vicinity of the public water supply wells.

WAC 173-160-171(3) provides an additional regulatory requirement that makes the use of groundwater in the vicinity of the Skykomish site unlikely. WAC 173-160-171(3) requires that wells shall not be located within certain minimum distances of known or potential sources of contamination, including septic systems. The minimum setback specified in WAC 173-160-171(3)(b) is 50 feet from a septic tank, septic holding tank, septic containment vessel, septic pump chamber, and septic distribution box and 100 feet from the edge of a drain field. It is estimated that the commercial and residential portions of the site are all subject to this setback requirement, as the property owners all use septic systems for wastewater management. These regulatory requirements, along with the availability of public water supply, make use of shallow groundwater in the vicinity of the site as a potential source of drinking water highly improbable.

Other potential users of groundwater are industry, businesses and agriculture. In order to extract groundwater for these uses, groundwater wells are required. There are no known existing groundwater extraction wells for agriculture in Skykomish, nor are there industrial processes with high water demand which may desire groundwater extraction to support these processes. Siting for wells to be used for industrial, commercial, and agricultural is also required to meet the setback requirements in WAC 173-160-171(3). As such, there is no current or reasonable potential future human use of groundwater in Skykomish. However, since the criterion listed in WAC 173-340-720(2)(b) is not applicable to the site, in cannot be determined that groundwater is not a potential future source of drinking water.

Despite the unlikelihood of human use of groundwater in Skykomish, cleanup actions for groundwater in Skykomish must prevent direct or indirect violations of surface water, sediment, soil, or air cleanup standards (WAC 173-340-720(1)(c)). As groundwater discharges to the South Fork Skykomish River and, at times, to the former Maloney Creek channel, highest beneficial use of these water bodies must be protected; that is, groundwater must be protected as a potable water source.

4.4.1.5 Surface Water

WAC 173-340-730(1)(a) states that cleanup standards for surface water (South Fork Skykomish River and former channel of Maloney Creek) are "based on estimates of highest beneficial use and the reasonable maximum exposure expected to occur under both current and potential future site use conditions." WAC 173-201A defines the Skykomish River as a Class AA river. Characteristic uses of Class AA rivers include water supply (domestic, industrial, agricultural), stock watering, fish and shellfish, wildlife habitat, recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment), commerce and navigation. As discussed above, the water supply for Skykomish comes from wells upgradient of the town, not from the South Fork Skykomish River. However, this does not preclude downstream use of the river for any of these purposes.

4.4.2 Potential Receptors

For the purposes of this exposure assessment, receptors and receptor activities are identified based on the highest beneficial use of each resource, as required in WAC 173-340-708(3)(b). This section discusses receptors that may be present at the site, based on the beneficial uses identified in the previous section, and observed land and water uses in the Skykomish area.

4.4.2.1 Residents

The highest beneficial use of most of the railyard is industrial. However, trespassers have been observed on the railyard and have the potential to contact surface soil. Trespassers are assumed to visit the railyard only briefly (in transit across the railyard) and are typically not frequenting areas where access is limited by fencing.

Residential use is the highest beneficial use of property off the railyard. Current and future residents of the Town of Skykomish may garden or landscape in the surface soil (i.e., off railyard property), and may have basements that extend into the impacted subsurface soil. Residents do not typically excavate to subsurface soil.

4.4.2.2 Industrial Railyard Workers

Industrial railyard workers are typically not engaged in construction work that would involve excavation on the railyard. However, these workers may directly contact surface soil during day-to-day maintenance activities.

4.4.2.3 Construction and Utility Workers

Construction and utility workers engaged in excavation work on or off the railyard have the potential for exposure to surface soil, subsurface soil, and groundwater.

4.4.2.4 Recreational Users of the South Fork Skykomish River

Humans use the South Fork Skykomish River for recreational purposes, such as rafting, kayaking, fishing, and boating. Thus, the potential exists for human receptors to contact contaminated surface water and sediments of the South Fork Skykomish River, and to ingest fish from the river.

4.4.2.5 Terrestrial Ecological Receptors

Under WAC 173-340-7490(2), a terrestrial ecological evaluation must be performed unless conditions allowing exclusion of such evaluation are met. Ecology has determined that a site-specific terrestrial ecological evaluation must be performed. A full terrestrial ecological evaluation was completed and submitted to Ecology on March 26, 2004, and it is included as Appendix D. The TEE concluded that TPH risks to soil invertebrates are present throughout the site, and developed a site-specific cleanup level (SSCL) of 1,870 mg/kg TPH. The TEE also found that, while risks are potentially present on the railyard the pathway is incomplete, and therefore the SSCL would not apply to the railyard. BNSF completed the TEE at Ecology's direction, but continues to respectfully disagree with the agency's policy of treating developed residential areas as "contiguous undeveloped land" under WAC 173-340-7490(1)(c)(ii).

4.4.2.6 Ecological Receptors in the South Fork Skykomish River

The South Fork Skykomish River is habitat for fish, shellfish, and sediment-dwelling organisms, as discussed in Section 2.2.6. These are the most sensitive users of the surface waters near the site. Other potential downstream receptors (e.g., water users) encounter very low contaminant concentrations, due to the dilution that occurs within the river. Downstream receptors typically involve larger organisms (i.e., livestock), which tend to be less sensitive to low-level contaminant exposures. Cleanup actions to protect in-stream organisms will protect downstream water users.

4.4.2.7 Ecological Receptors in Former Maloney Creek Channel/ Wetlands

Ecological receptors in wetlands are present in and around the former Maloney Creek channel. Fish use the wetland and ditches connected to the wetland. The wetland characteristics, habitat and potential ecological receptors are characterized in Section 2.2.6 and Appendix B.

The same assumptions cited above for the South Fork Skykomish River apply to the former Maloney Creek channel. The ecological receptors in the creek are considered the most sensitive receptors, and scenarios evaluating these receptors will adequately address potential impacts to other downstream receptors.

4.4.3 Transport Mechanisms

Figure 4-3 depicts the mechanisms (shown with purple arrows) by which contaminants (summarized in Section 4.2) can be transported and thereby lead to a potential exposure to the receptors described in Section 4.4.2. These mechanisms are summarized below.

4.4.3.1 Surface Soil to Water

Contaminants in surface soil may be mobilized (dissolved or sorbed to soil particles) by stormwater. The stormwater may then infiltrate to groundwater, or may travel over the surface, generally to storm drains, which in turn, lead to the South Fork Skykomish River. During flood events there is potential of free product being carried to the ground surface by groundwater. This would only occur if the groundwater rose above the ground surface during a flood, and even then, is only likely to occur close to the barrier wall. If this occurred, there would be potential for oil to be carried away with the flood waters. There is no evidence that this has ever occurred anywhere within the Site.

4.4.3.2 Free Product to Water

Free product moves in the direction of groundwater flow under potentiometric forces (i.e., hydraulic gradient). Contaminants enter the dissolved phase of groundwater after leaching from soil or free product or following infiltration of contaminated stormwater. The dissolved phase contaminants are then transported with the movement of groundwater. Groundwater at the site moves toward, and discharges to, the South Fork Skykomish River.

4.4.3.3 Soil, Groundwater, and Free Product to Indoor Air

Contaminants sorbed to surface soil (e.g., on the railyard) can be transported by wind. Wind-blown transport of lead and arsenic from soil to air is a complete exposure pathway, and will be evaluated further in this document. As shown on Figure 4-3 and discussed in Section 3.6, volatilized contaminants may be present in ambient air or may accumulate in confined spaces. See Section 2.4.3 regarding interim actions being taken by BNSF to control dust.

4.4.4 Potential Receptor Exposures

This section discusses the potential for receptors to encounter IHSs via one of the exposure or transport mechanisms identified previously. Figure 4-3 depicts these potential receptor exposures (highlighted in green).

4.4.4.1 Industrial Worker Exposures (on Railyard)

Routine railyard industrial workers are typically engaged in maintenance work and have the potential for contact with contaminated surface soil on the railyard. Direct contact, inhalation and incidental ingestion are the potential means of industrial worker contact with surface soil. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Railyard industrial workers are unlikely to be involved in excavation work that could lead to contaminated subsurface soil and groundwater exposures. Further, exposure to contaminated storm water flow is considered a negligible exposure pathway.

4.4.4.2 Construction and Utility Worker Exposures (On and Off Railyard)

Construction and utility workers may be exposed to contaminated surface soil, subsurface soil and groundwater while excavating. Direct contact, inhalation and incidental ingestion are the potential means of worker contact with these contaminated media. Exposure to volatilized contaminants in outdoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Exposure to contaminated stormwater flow is considered a negligible exposure pathway.

4.4.4.3 Residential Exposures

Residents of the Town of Skykomish may contact contaminated surface soil off the railyard via direct contact or inhalation of soil transported off the railyard by wind. Exposure to volatilized contaminants in indoor air is considered to be insignificant, based on empirical data (Section 5.2.1.4). Residents who enter the railyard (trespassers) and come into contact with surface soil have the potential for occasional and very minor short-term exposures to surface soils. Residents who conduct redevelopment work on their homes may be exposed to contaminated subsurface soils, groundwater, vapors and free petroleum product. However, deep excavation work is typically contracted out to commercial workers.

4.4.4.4 Terrestrial/Ecological Exposures

Terrestrial receptors have the potential for exposure to contaminated groundwater at the riverbank, where groundwater discharges to the South Fork Skykomish River. Deep roots of plants or terrestrial receptors drinking water near the potential groundwater discharge locations in the South Fork Skykomish River or former Maloney Creek channel may ingest groundwater.

Groundwater may recharge the former Maloney Creek channel during prolonged periods of heavy precipitation coupled with a rise in groundwater table. During these conditions, aquatic organisms have the potential to come into contact with contaminated groundwater.

4.4.4.5 Recreational User Exposures

Recreational users of the South Fork Skykomish River have the potential to come into contact with contaminated groundwater and free product at the riverbank (direct contact and incidental ingestion) where groundwater discharges to the South Fork Skykomish River. Further, recreational users of the river may contact surface water that has been impacted by contaminated groundwater (and free product LNAPL) discharges to the river. Exposure to contaminated surface water further away from the riverbank is a minor risk as the fast-moving surface water flow quickly dilutes the upland discharges to inconsequential contaminant concentrations.

4.5 Summary

The information presented in this section serves as the foundation for development of cleanup standards and cleanup action alternatives under MTCA. As presented in Section 5, cleanup levels are developed for the IHSs based on their potential for migration to other media and for exposure to various human and ecological receptors.

Figure 4-3 illustrates the complete human and ecological conceptual site model. This figure illustrates how the IHSs can potentially affect human health and ecology by migrating through soil, stormwater, groundwater, and surface water to potential receptors. In summary, complete exposure pathways are summarized in the following sections by media. They are summarized by media because cleanup levels are developed for each receptor by media in Section 5.1. The cleanup actions that will mitigate these exposure pathways are described in the following sections of this report.

4.5.1 Soil

The following human populations have the potential for exposure to soil:

- Industrial Worker (on railyard) to surface soil
- Construction and Utility Workers (on and off the railyard) to surface and subsurface soil
- Residents (on railyard) to surface soil
- Residents to subsurface soils (off the railyard while excavating)
- Residents (on and off railyard) through the soil to outdoor air by exposure to vapors or windblown particulates.

In addition,

- Terrestrial receptors have the potential for exposure to soil
- IHSs in soil can migrate to groundwater; therefore, cleanup levels are developed in Section 5 for concentrations of soil that protect groundwater.

As such, in Section 5, cleanup levels are developed for human health, ecology, and soil concentrations that protect groundwater.

4.5.2 Groundwater

The following summarize potential receptors to IHSs in groundwater:

- Construction and Utility Workers (on and off the railyard to groundwater while excavating)
- Residents (off the railyard to groundwater while excavating)
- Receptors to sediment due to the transport mechanism of groundwater to sediment
- Aquatic receptors to surface water due to the transport mechanism of groundwater to surface water
- Recreational users of the South Fork Skykomish River and Maloney Creek due to the transport mechanism of groundwater to surface water.

As such, in Section 5, cleanup levels are developed for human health, groundwater concentrations that protect sediment, and groundwater concentrations that protect surface water.

4.5.3 Sediment

The potential receptors to IHSs in sediments are biota that dwell in, and feed on and from, the sediment.

4.5.4 Surface Water

No IHSs other than TPH have been detected in surface water; however, surface water (specifically South Fork Skykomish River and Maloney Creek) directly affects recreational, terrestrial, and aquatic receptors. To ensure that the health of these receptors is protected, groundwater IHSs are used to calculate cleanup levels for these receptors.

Cleanup levels are developed for human health and ecological receptors in Section 5.

5 Cleanup Standards

MTCA provides the framework for evaluating and selecting cleanup actions, as described in Section 1.1. Within this framework are threshold requirements that must be met by all cleanup actions. The threshold requirements for cleanup actions, as defined in WAC 173-340-360(2)(a), are to:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal law
- Provide for compliance monitoring.

Other MTCA requirements for cleanup actions, as identified in WAC 173-340-360(2)(b), are to use permanent solutions to the maximum extent practicable, to provide for a reasonable restoration time frame, and to consider public concerns raised on the draft cleanup action plan during the public comment period. WAC 173-340-360(2)(c) through (h) identifies additional minimum requirements for cleanup actions. The potential for human health and ecological exposures to the IHSs at the site were evaluated in Section 4. This section develops cleanup standards for the site that protects these human health and environmental receptors. This section also identifies the state and federal laws that are applicable to the site and cleanup actions at the site. As described in Section 1.1, under MTCA, cleanup standards consist of the following:

- The concentration of a hazardous substance that protects human health and the environment (cleanup level)

- The location on the site where the cleanup level must be attained (point of compliance)

- Other regulatory requirements that apply to a cleanup action because of the type of action and/or the location of the site.

Each of these is discussed below, to the extent necessary. Subsequent sections of this FS identify and evaluate alternative means of achieving site cleanup.

5.1 Indicator Hazardous Substances

IHSs in addition to TPH were identified through a detailed screening process, as described in Section 3.8 and Appendix G. The IHSs applicable to different media, in addition to TPH, are also summarized in Section 3.8 and include lead, arsenic, and some PAHs. Cleanup standards are developed later in this section for comparison to site concentrations, and in many cases the cleanup levels will be the same as the screening levels used to select the IHSs in Appendix E.

5.2 Cleanup Levels

Cleanup levels under MTCA are defined as the concentrations of hazardous substances that are protective of human health and the environment under exposure conditions (e.g., the exposure scenarios developed in Section 4). Cleanup levels are developed for IHSs in media that pose a threat to human and ecological receptors, as summarized in Section 4.4. The relevant IHSs were identified in Section 3.8 and Appendix G for soil, groundwater, sediment, and surface water. Ecology has requested that applicable MTCA cleanup levels be compiled for all 16 PAHs, PCBs, lead and arsenic for all media for completeness although many of the PAHs, PCBs, lead and arsenic were not identified as IHS for some or all media based on the screening in Section 3.8 and Appendix G.

MTCA provides three methods for developing cleanup levels for soil, groundwater and surface water:

1) Method A defines cleanup levels for 25 common site chemicals and is generally designated for routine cleanups

2) Method B determines cleanup levels at sites using a site-specific risk assessment with cancer risk levels established at 10^{-6} for individual carcinogens and 10^{-5} for total site risk, and non-cancer risk at or below a hazard index of 1

3) Method C determines cleanup levels for specific site uses (i.e., industrial) using site-specific risk assessment when Method A and B levels are technically impossible to achieve.

Since the cleanup for the site is not considered routine, Method A values will not be used for this site. Method B cleanup levels are applicable to all sites and will be used at this site. Although the railyard is zoned for industrial use, the off-railyard areas are zoned residential, commercial, municipal, and educational; therefore, Method C cleanup levels will not be used. Method B will be used to develop cleanup levels for soil, groundwater and surface water for all areas of the site.

MTCA also requires that cleanup levels for each media be at least as stringent as the concentrations established under applicable state and federal law. The applicable state and federal standards for each media will be identified in the following subsections. Figure 5-1 illustrates the general approach to setting Method B cleanup levels at the site.

Sediment cleanup standards are defined under MTCA in WAC 173-340-760, which requires compliance with WAC 173-204 (Sediment Management Standards [SMS]). Under WAC 173-204-520(1)(d), freshwater sediment cleanup screening levels and minimum cleanup levels are determined on a case-by-case basis consistent with the intent of the SMS, which is to "eliminate adverse effects on biological resources and significant health threats to humans" (WAC 173-204-100(2)).

Cleanup levels are set for soil, groundwater, sediment, and surface water. For each of the environmental media, potential exposures to human health and the environment were evaluated in Section 4. Those exposures include the potential migration of IHSs from one media to another. For example, soil cleanup levels must not only protect the people who may come into direct contact with the soil, but also ensure that the ground water cleanup levels are not exceeded. For each of those potential exposure pathways, including the exposure to other media, protective concentrations must be developed (refer to Figure 5-1 for the relationship between cleanup levels for the various media). The cleanup level is the most stringent of those concentrations.

5.2.1 Soil

Consistent with the potential complete exposure pathways discussed in Section 4.4, cleanup levels are developed for human and ecological (terrestrial) receptors in this section. In addition, cleanup levels are developed for soil for two transport mechanisms: soil to groundwater and soil to air. The soil cleanup levels are established in accordance with WAC 173-340-740.

Under Method B, soil cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect the environment (terrestrial ecological receptors)
- Concentrations that protect ground water quality
- Concentrations that protect air quality.

5.2.1.1 Concentrations that Protect Human Health

The establishment of soil cleanup levels that are protective of human health depends on the reasonable maximum exposure expected to occur under both current and future site use conditions. MTCA defines "reasonable maximum exposure" as the highest exposure that can be reasonably expected to occur for a human or other living organisms at a site under current and potential future site use [WAC 173-340-200]. As described in Section 4.4.1, land use across the site varies. The rail yard is currently used as industrial property by BNSF, and the most likely future use of the property is industrial. The highest beneficial use of off rail yard properties is residential. The regulation allows for the establishment of soil cleanup levels based on two types of land use: unrestricted land use and industrial land use. Unless a site qualifies as an industrial property, soil cleanup levels must be based on unrestricted land use. See WAC 173-340-745(1).

At the site, although the rail yard is an industrial land use, the surrounding areas are residential, commercial, and recreational. Consequently, soil cleanup levels will be based on unrestricted land use.

Soil cleanup levels protective of human health were determined using Equations 740-1, 740-2 and 740-3 (WAC 173-340-740) based on a soil direct contact exposure pathway.

PAHs

Values for the PAHs were obtained from the CLARC v3.1 (Ecology, 2001a).

Total PCBs

Method B values for PCB mixtures are not available. However, the Method A Soil Cleanup Level for total PCBs is 1 mg/kg, based on applicable federal law.

Metals

For arsenic, the MTCA Method B cleanup level is the Ecology background concentration of 20 mg/kg. The MTCA Method B value for lead will be the cleanup level that is based upon preventing unacceptable blood lead levels and calculated by the IEUBK model (250 mg/kg).

Total Petroleum Hydrocarbons

Ecology prepared a technical memorandum (Ecology, 2004) that sets forth the various TPH cleanup levels applicable to the site and documents their derivation. The Method B soil TPH cleanup levels for unrestricted land use are based on the *Worksheet for Calculating Soil Cleanup Level for Direct Contact Pathway: Method B – Unrestricted Land Use (MTCATPH10.xls)* spreadsheet tool provided on Ecology's website was used to perform the calculations required by Equation 740-3 for petroleum mixtures. Petroleum hydrocarbon fractionation data obtained from EPH/VPH analysis of soil samples was used to perform the calculations. A technical memorandum documenting the procedures used for establishing the EPH/VPH dataset is included as Appendix H. See Appendix I for information regarding other site-specific input parameters for the four-phase model.

Iterations of the model were made for each sample to ensure that the back-calculated TPH concentration satisfied four sub-criteria:

1) Hazard index = 1
2) Total cancer risk =1 x 10^{-5}

3) Cancer risk due to benzene = 1 x 10^{-6}
4) Cancer risk due to cPAHs = 1 x 10^{-6}.

The median TPH concentration was selected as the cleanup level for a specific soil zone. Cleanup levels based on direct contact and developed by Ecology for the vadose and smear zone soil are 2,130 and 2,765 mg/kg TPH (by EPH/VPH method), respectively. Ecology assumed TPH was present at half the detection limit for TPH fractions that were not detected. Ecology also assumed direct contact by a child ingesting 200 mg of soil per day for 6 years, and an acceptable cancer risk of 1 in 100,000.

5.2.1.2 Concentrations that Protect the Environment

Terrestrial Ecological Evaluation

The establishment of soil cleanup levels that are protective of the environment requires a terrestrial ecological evaluation (TEE) under certain circumstances. The regulation establishes a tiered process for evaluating potential risks to terrestrial ecological receptors. This process is set forth in WAC 173-340-7490 through 173-340-7494. WAC 173-340-7491 provides for specific exclusions from the TEE requirements. Certain site circumstances provide an exclusion from any further ecological evaluation at a site because the contaminants either have no pathway to harm the plants or animals, e.g., they are under buildings or deep in the ground; or there is no habitat where plants or animals live or forage near the contamination; or finally, the contamination does not occur at concentrations higher than what is found naturally occurring in the area. Ecology has determined that residential areas around the railyard are “contiguous undeveloped property” such that the site does not qualify for an exclusion. At Ecology’s direction, BNSF prepared a site-specific TEE per WAC 173-340-7493. This evaluation is included in Appendix D along with subsequent, related Ecology correspondence dated April 23, 2004.

Ecology has determined the following soil cleanup level necessary to protect terrestrial invertebrates, such as earthworms: 1,870 mg/kg NWTPH-Dx. A separate site-specific value was not developed for plants because there are no available toxicity reference values. For protection of wildlife (mammalian herbivores such as shrews and avian predators such as owls), the MTCA default value of 6,000 mg/kg NWTPH-Dx may be appropriate for areas of the site where this exposure pathway is of concern. Ecology did not require a soil cleanup level for non-petroleum contaminants.

Environmental Effects

Ecology’s December 10, 2004 technical memorandum sets forth a TPH concentration in soil of 175 mg/kg NWTPH-Dx and VPH/EPH calculated using the four-phase model that results in no adverse effects in the propagation of wildlife, fish, and other aquatic life. This cleanup is based on the groundwater-to-surface water pathway, groundwater cleanup level of 700 μg/L NWTPH-Dx. The 700 μg/L NWTPH-Dx groundwater cleanup level is, in turn, based upon whole effluent toxicity testing (WET testing) as discussed below in Section 5.2.4.2.

Sediment Recontamination

As discussed in Section 5.2.2.2, groundwater concentrations must not exceed 208 μg/L NWTPH-Dx and VPH/EPH to protect aquatic organisms in sediment. Using the four-phase model, Ecology calculated the soil concentration needed to ensure that groundwater meets 208 μg/L NWTPH-Dx and VPH/EPH (Ecology, 2004). The median value resulting from calculations performed using the VPH/EPH data set is 22 mg/kg NWTPH-Dx and VPH/EPH.

5.2.1.3 Soil Concentrations that Protect Groundwater

Ecology's December 10, 2004 memorandum sets forth the following cleanup level for TPH in soil to protect groundwater – 77 mg/kg VPH/EPH. This value is based on four-phase model calculations to yield a soil TPH concentration that is protective of groundwater to drinking water quality (i.e., hazard index of one).

Ecology has also determined that a vadose zone soil cleanup level protective of groundwater is equal to the MTCA default residual saturation value of 2,000 mg/kg NWTPH-Dx (Ecology, 2004). This value is based on preventing groundwater contamination by gravity flow of fresh diesel from the vadose zone to the groundwater table.

5.2.1.4 Soil Concentrations that Protect Air

Metals

Constituents in soil that could impact air include wind-blown arsenic and lead to outdoor air. Arsenic and lead are identified as IHSs for soil. As discussed in Section 4, a potential exposure pathway that must be addressed is particulate dispersion and subsequent inhalation of these compounds. However, the MTCA Method B cleanup levels shown in Table 5-1 based on direct contact are also protective of this exposure pathway. Therefore, the most stringent soil cleanup levels for lead and arsenic are 250 and 20 mg/kg, respectively.

TPH

As set forth in Ecology's December 10, 2004 technical memorandum, the cleanup level for TPH in soil to protect air is 2,900 mg/kg. This value was derived using the four-phase model and the average VPH/EPH composition of the six available vadose zone samples.

Selected Soil Cleanup Level

Ecology has determined that the lowest soil cleanup level concentration is 22 mg/kg NWTPH-Dx and VPH/EPH and, hence, is the soil TPH cleanup level for the site. MTCA allows for use of the practical quantification limit (PQL) as the cleanup level if the cleanup levels derived under Method B are lower than the PQLs achievable by the laboratory analytical method used to measure concentrations. The PQL for VPH/EPH is 5 mg/kg for each hydrocarbon fraction in soil or sediment. For a total of 12 hydrocarbon fractions, the PQL is 60 mg/kg. The PQL for NWTPH-Dx is 25 mg/kg for petroleum hydrocarbons consisting primarily of diesel fractions. However, the NWTPH-Dx method also indicates 100 mg/kg is the expected PQL for a heavy oil product (Ecology, 2004). The manner in which PQLs and method detection limits will be handled during compliance monitoring has not yet been determined. Thus, 22 mg/kg VPH/EPH is the lowest value of the above soil cleanup levels.

5.2.2 Groundwater

As summarized in Section 4.4, cleanup levels are developed for human receptors in this section. In addition, cleanup levels are developed for two transport mechanisms: groundwater to sediment and groundwater to surface water. The groundwater cleanup levels are established in accordance with WAC 173-340-720.

Under Method B, groundwater cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect sediment quality
- Concentrations that protect surface water quality.

5.2.2.1 Concentrations that Protect Human Health

The establishment of groundwater cleanup levels that are protective of human health depends on the classification of groundwater as either potable (a current or potential source of drinking water) or non-potable. The classification of groundwater depends on the highest beneficial use expected to occur under both current and future site use conditions. Although site groundwater is not considered a source of potable water, the highest beneficial use of water must be protected as a potable source, as groundwater recharges to the South Fork Skykomish River and potentially to the former Maloney Creek channel.

Groundwater cleanup levels that protect human health through the groundwater ingestion pathway can be calculated by using MTCA Method B and also by considering drinking water standards established under applicable state and federal laws. These include:

- MCLs established under the Safe Drinking Water Act (SDWA)
- Maximum contaminant level goals (MCLGs) for noncarcinogens established under the SDWA
- Secondary MCLs established under the SDWA
- MCLs established by the state board of health.

The MTCA Method B criteria for PAHs, PCBs, arsenic and lead were obtained from the CLARC v3.1 table (Ecology, 2001a).

Per WAC 173-340-720(4)(b)(iii)(C), Ecology's *Worksheet for Calculating Method B Potable Ground Water Cleanup Levels (MTCATPH10.xls)* was used to perform the calculations required by Equation 720-3 for petroleum mixtures. Ecology performed model runs using the entire VPH/EPH groundwater dataset. Iterations of the model were made to ensure that the back-calculated TPH concentration satisfied four sub-criteria:

1) Hazard index = 1
2) Total cancer risk =1 x 10^{-5}
3) Cancer risk due to benzene = 1 x 10^{-6}
4) Cancer risk due to cPAHs = 1 x 10^{-6}.

Ecology derived a TPH cleanup level of 477 μg/L VPH/EPH in groundwater that would be protective of human health based on potable use. The limited groundwater VPH/EPH dataset for the site contains very few detected TPH fractions. As a result, this cleanup level is skewed by TPH fractions that have never actually been detected in groundwater (where half of the detection limit is used as input in the model) and by the assumed distribution of these TPH fractions that have never been detected in groundwater. During the remedial design process and the initial phases of long-term groundwater monitoring, additional EPH/VPH groundwater data will be collected and this cleanup level can be refined, as appropriate.

5.2.2.2 Concentrations that Protect Organisms in Sediment

Ecology has set forth the cleanup level for TPH in groundwater to protect sediments as 208 μg/L NWTPH-Dx and VPH/EPH (Ecology, 2004).This value was calculated using the EPA Equilibrium Partitioning Model for Sediment, assuming a hydrocarbon distribution derived from a sediment sample analyzed by VPH/EPH methodology. This concentration protects against sediment recontamination above the numeric sediment cleanup level of 40.9 mg/kg NWTPH-Dx (See Section 5.2.3).Concentrations that Protect Beneficial Uses of Surface Water

Because groundwater discharges to the Skykomish River and the former Maloney Creek channel, groundwater cleanup levels must also be sufficiently stringent to ensure that groundwater does not cause surface water to exceed cleanup levels established for surface water based on human health protection. As presented in Section 5.2.4, 500 µg/L NWTPH-Dx based on fish consumption and 477 µg/L VPH/EPH based on potable water use are protective of surface water.

5.2.2.3 Selected Groundwater Cleanup Level

The most stringent criteria for TPH in groundwater, 208 µg/L NWTPH-Dx and VPH/EPH, is based on protection of aquatic organisms in sediment (refer to Table 5-1). However, since some of the cleanup levels in Table 5-1 are lower than practical quantitation limits (PQLs), cleanup levels for groundwater and surface water are compared to the PQLs. The published PQL is 50 µg/L per VPH EC range. Historically, a PQL of 20 µg/L per EPH EC range has been achieved. A PQL of 250 µg/L is established in the NWTPH-Dx method for petroleum hydrocarbons consisting primarily of diesel fractions. However, the method also indicates 500 µg/L is the expected PQL for a heavy oil product. The application of PQLs and method detection limits will be addressed in a compliance monitoring plan, as required by MTCA.

5.2.3 Sediment

As summarized in Section 4.4, cleanup levels are developed for ecological receptors including fish, shellfish and sediment-dwelling organisms in this section. The IHSs in sediments at the site include lead, PAHs and TPH.

Sediment cleanup standards are defined under MTCA in WAC 173-340-760, which requires compliance with WAC 173-204 (Sediment Management Standards [SMS]). Under WAC 173-204-520(1)(d), freshwater sediment cleanup screening levels and minimum cleanup levels are determined on a case-by-case basis consistent with the intent of the SMS, which is to “eliminate adverse effects on biological resources and significant health threats to humans” (WAC 173-204-100(2)). Sediment quality standards are determined within the range set by the sediment cleanup objective of no adverse effects at the minimum cleanup levels (WAC 173-204(4)).

No chemical specific cleanup criteria have been defined for freshwater sediments (WAC 173-204-520(1)(d)). Procedures for setting cleanup levels in Puget Sound marine sediments using sediment toxicity bioassays are defined in WAC 173-204-570. An approach similar to the procedures defined for marine sediment was applied at this site, using site-specific acute and chronic sediment toxicity bioassays on a suite of three species (Microtox®, *Hyalella azteca*, and *Chironomus tentans*) analogous to the marine sediment procedures. The bioassay results are presented in Appendix A and can be used to define the area of impacted sediments requiring cleanup.

Based on the bioassay results in Appendix A, Ecology has derived a sediment TPH value of 40.9 mg/kg NWTPH-Dx for use in back-calculating a groundwater cleanup level protective of sediment dwelling organisms (see Section 5.2.2.2) (Ecology, 2004). Thus, 40.9 mg/kg NWTPH-Dx is the numeric sediment cleanup level. However, Ecology has determined that bioassay pass/fail results may be used in lieu of or in combination with chemical analyses of sediments (Ecology, 2004) to define the area of sediment requiring cleanup. This performance based cleanup level will be referred to as "the bioassay cleanup level for sediment" throughout the remainder of this document. PQLs for sediment are the same as those reported for soil in Section 5.2.1.5. The application of PQLs and method detection limits will be addressed in a compliance monitoring plan, as required by MTCA.

5.2.4 Surface Water

The surface water cleanup levels are established in accordance with WAC 173-340-730.

Under Method B, surface water cleanup levels must be at least as stringent as each of the following concentrations:

- Concentrations established under applicable state and federal laws
- Concentrations that protect human health
- Concentrations that protect the environment (aquatic ecological receptors).

5.2.4.1 Concentrations that Protect Human Health

The establishment of surface water cleanup levels that are protective of human health depends on the reasonable maximum exposure expected to occur under both current and potential future site use conditions. The reasonable maximum exposure for surface water at the site is discussed in Section 4.4 and is based on classification of the Skykomish River as a Class AA River. Therefore, the highest beneficial use of surface water at the site may include water supply, fish and shellfish, wildlife habitat, and recreation.

No IHSs were identified for surface water at the site except for TPH; however, as discussed in Section 4.4, groundwater at the site recharges to surface water. Therefore, it is necessary to establish groundwater cleanup levels protective of surface water, and to consider all groundwater IHSs in doing so. Per